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INTRODUCTION

THE management of a factory can be one of the most fascinating occupations. It provides ample scope for the whole variety of human characteristics and yields rewards for skill and perseverance not easily to be reaped elsewhere. There is a satisfaction to be experienced in creating something tangible, useful, and attractive from the most ordinary raw materials; a mental exhilaration accompanying the technical development of a most complex and astonishing device starting from a blank sheet of paper; and a thrill in seeing in movement a machine which has lived for months only in the minds of its builders. And in these days, when it is realized that utility and ugliness are not the Siamese twins of industrialism, the production of an article of beauty gives a sense of fulfilment to the artistic feeling present to some extent in all human beings. No general launching a campaign is to be envied by a man embarking on the production of a new article. A scientist finding at last the new material of perhaps arresting beauty, though derived from coal-tar and sawdust, has no more reason to feel satisfied than the manufacturer who picks up that material, has its properties tabulated, and its potentialities analysed, and then creates from it an article attractive, ingenious, and useful.

In the factory itself—apart from what it produces—there is again endless scope for genius. The welding together of a collection of human beings, each with his or her own ideas, ambitions, and characteristics, into an efficient, happy team is a never-ending task. The scheming of shop layouts to carve human effort down to the irreducible minimum; the analysis of human motions to adapt them to tasks undreamt of; the organizing of groups of unskilled people to produce at an incredible rate something completely beyond the capabilities of the master craftsman of a few years ago; the tooling to ensure perfection of performance and the maintenance of standards of quality; and the innumerable other activities essential to successful manufacture, provide all the opportunity that any man could ask to express the utmost of which he is capable.

The financial side also has its fascination. In some circles the average manufacturer is fondly pictured as a sort of super slave-driver wallowing in enormous profits, but anyone with experience in running a factory knows how wide of the mark this is. On the one hand competition holds down selling prices while, on the other,

the proper materials and the generous treatment of workers, without which no factory can build up a secure position, cost a great deal of money. It is no easy task to control the expenditure of thousands of pounds spent in manufacture to within a few per cent (on the right side) of income. In fact, this can be done only by sheer efficiency in organization since, under modern conditions, the only loophole for profit-making is in the avoidance of waste of materials and human effort.

In this book an attempt has been made to outline the fundamental principles of factory organization in readable language, with economy in paper and therefore in the reader's time. Where a problem has been dealt with in some detail, it is because it is of particular importance or because it has been neglected in existing books on the subject. Inevitably there are generalizations or statements which are given almost axiomatic force but, as the Author himself says, the man who maintains (at any rate in a factory) that there is only one way to do a thing is always wrong.

Where, therefore, precise examples of systems are given, it must not be assumed that these are recommended as being preferable or even suitable for any particular factory, but rather as illustrations to show the various factors which any system should take into account.

CONTENTS

FACTORY ORGANIZATION AND MANAGEMENT

CHAPTER I

FUNDAMENTAL POLICY

IT will not be disputed that a clear-cut policy is a valuable asset to any organization and that once a policy is established it is sound business to stick to it (unless, of course, it proves to be a failure) and to modify it only by small degrees. Even in modification it is as well to have a definite plan—a long-term policy covering the direction it is proposed to take in the future. All proposals affecting the fundamental running of the business ought to conform to the policy agreed and therefore the temptation to embark on a proposition which conflicts with it must be resisted, no matter how attractive that proposition may appear when considered by itself.

It is possible and, in fact, quite common to make a living by selling things without making anything at all, although the converse scarcely holds. While many factories are established by companies formed for the purpose, the majority are probably opened by companies which already exist in some form or another, and quite often by a concern, which has existed by selling alone, extending its activities to manufacture.

Selling or Manufacturing

However and whatever the previous history may be, it is important that the directors of a company proposing to open a factory should first make up their minds whether the business which they control is primarily for selling or primarily for manufacturing, because a decision on this point and a definite policy based on it will save them a great deal of trouble in the future. In any event it is better to keep selling and manufacturing activities apart. Certainly separate accounts should be kept and preferably two entirely separate organizations should be formed. The reasons for this are—

(1) The organization of sales activities differs considerably from the organization of a factory and, if the two are completely separate,

then they can each adopt exactly what arrangements they require to give the maximum efficiency without considering the other.

(2) The characteristics of a good sales manager are to a large extent undesirable in a works manager and vice versa, so that two very different types of men are required to supervise the two activities.

(3) The statistics required to exercise control over a sales organization are quite different from those required to exercise control over a factory, and should be presented and used in a different manner. If there is no separation, then the statistics for the business as a whole are enormously complicated and correspondingly difficult to use in the exercise of effective control.

(4) If they are completely separate, then either organization may undertake activities independent of the other if and when required to maintain a favourable financial position.

(5) Except in a jobbing shop, that is to say, as soon as there is any degree of mass production, the sales organization can and should be made responsible for forecasting requirements and for stocks of finished goods. The sales organization should be required to issue bulk orders to the factory and to accept responsibility for finished goods as they are completed and delivered to the stores by the factory. Where it is advisable to issue part orders, the sales organization must still accept the responsibility for the orders and for the stock of finished parts. For instance, in the manufacture of small electric motors it might be advisable to place an order for, say, 5000 sets of parts for one particular size, but to proceed with the winding of only 1000 until sales show in what proportion the windings are required for different voltages, etc. In such a case the sales organization would place the order for the 5000 sets of parts and would be debited with them as they were made.

Permissible Stocks *v.* Stock Orders

A suggestion which is made where production is in batches is that the sales department should lay down "permissible stocks" of finished goods which virtually fixes the size of batches for assembly, leaving it to the factory to work out its own figures for batches of component parts and orders for raw materials. This avoids the possibility of large stocks of finished goods, but presents other objections outweighing this. It is true that, within reason, the economic batch for assembly can be regulated to suit the sales organization, but the economic batch for parts to be made in a machine shop may be a very different matter. Also, in order to get

economic prices and to avoid production hold-ups, the buyer must order raw materials or finished components in as large quantities as possible. Then, although work can be stopped on the manufacture of component parts in the factory when the action of the "permissible stock" rule comes into force, the same action cannot necessarily be taken with an outside supplier manufacturing component parts; therefore the flow of these cannot be stopped.

Consequently, therefore, the stocks of component parts will be greater than the "permissible stock" of finished articles and, if each component is treated on its own merits, there would be a considerable degree of unbalance in the factory stocks which would complicate the work of the materials control section and introduce very many opportunities for production hold-ups due to the lack of a certain part when production is resumed after a deliberate stop.

If a policy of straightforward stock orders is adopted, the factory is given the best chance of manufacture at minimum cost, but it is quite possible that the adoption of a policy designed to eliminate the accumulation of excessive stocks of finished articles might cost more by way of inefficiency in the factory than the saving represented by the interest on the capital value of the additional stocks. Finally, there appears to be no reason why the sales organization should be relieved of the responsibility of avoiding the accumulation of excessive stocks of finished materials. In the case of a business which exists primarily for manufacturing they would either sell the goods or find that the factory had created another outlet which weakens their future position. In the case of a factory belonging to what is essentially a selling organization, it would place the factory in an unfavourable position in comparison with an outside supplier and might lead to the erroneous conclusion that the company would do better to revert to its original policy of buying the complete article instead of having it made in its own factory.

The Separate Factory

An existing selling company going into manufacture should, therefore, preferably form a separate company to run the factory, choosing a factory man as principal of that company. The parent company will then continue to choose its lines by selecting those it can sell most profitably, the factory gradually taking over the manufacture of some or perhaps all of those lines one by one. The

perpetual problem which the directors will have before them is, on the one hand, not to allow the sales side to force the factory into making something just because they would like to have it to sell and, on the other, not to allow the factory to tell the sales people that they must sell another article because it suits the factory to make it. At the outset it must be realized that new lines will be chosen purely for their value as selling propositions and this means that the sales side will probably always have to continue to factor goods of another manufacture. If the factory is obliged to "sell" a new line to the sales organization before they can start making it, they will be provided with a very good safeguard against failures. No doubt if the man running the factory is a good choice, he will be constantly trying to expand, but if the directors always bear in mind that they are running an organization which is primarily for selling, they will always treat the factory as a secondary activity and will not side with the factory manager when he tries to "sell" a new proposition. The factory should not be opened at all unless it can be run profitably on the manufacture of established lines, and expansion thereafter should be on the sales side first.

If, however, the organization is primarily for manufacturing, new lines will be chosen to suit the factory and only abandoned if all sales outlets fail. The sales side should be built up only to the extent necessary and there must be no hesitation in using other outlets or in regulating the size of the sales force to conform strictly to its value to the factory. For example, the factory may be able to come to an arrangement whereby it will make a certain line for a selling company or a large user, and an accumulation of such business may ultimately enable the factory to reduce its selling staff to no more than an order department with a number of technical representatives to maintain contact with the customer.

The directors of such an organization must never let their sales force dictate policy, although, of course, the ideas of the sales force must not be ignored. But this time the sales people have to "sell" the proposition to the factory first and this gives them some practice. Again, two distinct selling methods, for example, are direct or "through the trade." The directors of what is primarily a manufacturing concern will not hesitate to break away from one of these methods and embark on the other if they find that competition in the type of article which suits the factory calls for such a change. In the case of a selling company having an ancillary factory, stability of sales method would be essential and if, therefore, competition from people adopting a different sales method kills

business in a certain line, it will probably be decided that the line will have to go and the factory will have to make something else which suits the traditional sales method of the company.

Single or Multiple Lines

Having decided whether the factory is the dog and the sales organization the tail (primary factory) or vice versa (ancillary factory) and having decided to stick to whichever arrangement it is, the next important question to answer is whether the factory is to manufacture one or, at most, two or three lines, or whether it is to manufacture a multiplicity of lines. The layout of a single-product factory is very different from that intended to produce a variety and therefore a decision on this point is required at the outset. If it is an ancillary factory, the decision would depend to a great extent on what is being sold, but it may be possible to justify the establishment of a factory to make a single line for an existing selling organization which handles many different lines. In fact, provided the sales side can first build up the sales to sufficient volume, the subsequent establishment or the acquisition of several factories, each laid out for a particular line or group of related lines, is preferable to a single factory making a multiplicity of lines.

Where a choice is possible, it may be taken that the single-product factory is the way to make things cheaply and, therefore, so long as sales volume is assured, a profitable business can be obtained in the face of competition, but a factory which handles variety stands the best chance of weathering economic storms. From this it follows that an ancillary factory is more likely to be designed for a single product, while a primary factory is more likely to be established to manufacture a variety of products.

If the decision is to make a single product, then the tendency should be to make as much as possible of that product. That is to say, the development of the factory would be in two directions—first, along the normal direction of increased output to meet increased sales and, secondly, in the direction of making parts and components previously bought out. At the outset a clear understanding should be arrived at as to the precise degree to which manufacture is to be commenced. The decision on this point is very largely a matter of available finance, although many other considerations are involved. "Manufacture" may be anything from bare assembly of finished components to the complete production of a complex article from basic raw materials. It is extremely important to have a clear idea

in regard to exactly what degree of manufacture is intended and exactly what is involved in progressing from that stage.

The advantage of the "assembly" shop is that the minimum capital outlay in buildings and plant is required, although the capital to cover stock and work in progress may be high. This, however, depends on the rate of production and on how fast finished goods can be turned into money. Clever control may succeed in running such a business with no more money sunk in stock than a factory doing far more than the mere assembly and therefore requiring a large amount of additional capital for buildings and plant. The disadvantage of such a policy is that the factory is always at the mercy of a complex arrangement of sub-contractors and, since it works on a comparatively narrow margin, it calls for very strict control. The disadvantage attaching to a network of sub-contractors, however, may not be so real as imagined by the man who has to keep the arrangement working, and who always thinks his life would be easy if only he had the making of the various components under his own control. The thing which is fatal is to sink capital into a factory on a scale which would justify real manufacture and then to find that it is doing no more than assembly work.

Degree of Production

Once a factory has been established it must make as much of its product as it can. The best way to keep check on this is to fix a figure for the percentage of material consumption to turnover and to refuse to embark on any new project where the cost estimate shows a figure in excess of this percentage. For instance, a pure assembly shop might be run successfully although spending as much as 70 per cent of its income on material purchases, but a factory built on altogether more expensive lines in order to accommodate still more expensive plant could not afford to buy finished components, but would have to keep its expenditure on materials down below, say, 50 per cent of its turnover by making the components itself.

In a purely selling organization the touchstone would be "gross profit." Experience or calculation, or both, would show the percentage gross profit which must be made in order to show a net profit and no new line would be added unless it could be bought at a net price and sold competitively to yield this gross profit. In the same way, in a factory each new project should be examined in the light of material cost. Experience and calculation will show,

within very close limits, the percentage which will line up with what is being done already, or it will provide a valuable basis to work from if it is a case where a new factory is being established. It is sound policy in the one case not to add a new line in which the material percentage varies considerably from that in existing lines or, in the other case, not to set out with the idea of mixing in the same factory products having high and low material percentages.

Amalgamation

It is a fact that men having considerable financial experience often prefer to buy up an existing business rather than to establish an entirely new one. It is not proposed to discuss the merits of this policy, but something might be said in regard to the absorption of an existing manufacturing organization by a concern which already operates one or more factories. An additional factory should not be absorbed if its main products are similar to those of a factory already in the group. Such a suggestion usually comes from the sales side, but this is not the best way to overcome sales problems.

It may be quite a sound policy for a company which exists primarily for selling to buy up other selling organizations making similar products because the public preference for a certain brand is a valuable and curious thing. There may be no difference whatever between two brands of a certain product and yet in one part of the country the public will prefer one of them, and in another part of the country, the other, and the most strenuous efforts to sell the one brand in both districts would be a failure.

The amalgamation of two factories producing similar goods is a very different matter unless the object is to shut one down and increase the output from the other accordingly. If both are to be kept going, the first move would probably be to reduce the variety of products in both factories by arranging that the X factory ceases to make products A, B, and C so that the output of corresponding products in the Y factory can be increased, while the Y factory ceases to make products D, E and F as a *quid pro quo*. This, on paper, may be an attractive proposition but in actual practice it is far from being so. The staff in the X factory hitherto responsible for products A, B, and C will obviously exert their maximum efforts to prove that their brand is superior to that of the Y factory so that A, B, and C should still be made in the X factory. This will go on throughout the entire range of products so that, until someone puts his foot down, so much energy may be devoted to this preliminary skirmishing that the customers of both companies will be sadly neglected.

Then difficulties will be experienced in getting the salesmen of the X company to sell the products of the Y company instead of the corresponding products hitherto manufactured by their own company. For some extraordinary reason it will be found that, prior to the amalgamation, the X company's salesmen held the opinion to a man that the Y company's products were superior to their own and only maintained the opposite for business reasons. Immediately after the amalgamation their opinions reverse and nothing made by the Y company is ever as good as the article which used to be made by their old company.

Assuming these problems raised by the human factor are overcome, there still remain the enormous difficulties in connexion with the economic use of the plant of the combined companies. Unless the two factories happen to be situated very close to each other a unified management is scarcely possible and, for reasons discussed later, dual control is undesirable. Consequently, the two factories would probably have to continue as two separate entities each under its own manager and the utmost difficulty would probably be experienced in getting these two gentlemen to agree to any interchange of plant necessary to ensure more efficient production under a new allocation of products. In the end, the shareholders will probably find that they would have been better off if they had simply invested in the shares of the other company in the ordinary way instead of voting for the amalgamation.

Quality and Quantity Standards

A second consideration of importance is that of the quality standard to which the factory is to work. It is a fact that it is very difficult to get a factory which has been producing articles to a certain standard to produce something similar, but to a much higher or a much lower standard. Not only the manual workers but the whole staff have become educated to the existing standard and their whole outlook and methods revolve round it.

By way of example, take a factory which is producing high-class furniture and suppose it is decided to go into the manufacture of built-in kitchen equipment. It is assumed that the necessary alteration in the equipment of the factory is carried out thoroughly, but, even so, it will be found that the workers will either make much too good a job of the kitchen equipment so that it is not competitive on price or else, if they get down to the price, their work will probably not be equal to that coming from a factory already well established in this class of business, because they have abandoned

their traditional standard and only time will enable them to create a new one. It is not implied that the products of manufacturers of kitchen equipment are shoddy or anything but entirely suitable for the purpose, but simply that the standard of quality required is quite different from that demanded by the high-class furniture market.

Another problem which arises for similar reasons is the manufacture of products of high and low unit values in the same factory. To some extent this is due to the fact that an article of low unit value would, generally speaking, be produced on much more mass production lines than one of high unit value. If, therefore, a factory is producing articles of high unit value, it is better to avoid, if possible, the introduction of lines having low unit value, or vice versa.

Of course, both the questions of quality standards and unit value depend on the size of the factory and the extent to which it is departmentalized. The point is that to achieve success with a body of workers and staff, it is necessary to inculcate in them definite ideas in regard to quality and quantity, and this can be done only with reference to a fairly restricted class of products. They can be educated either to work down to a price or up to a standard and to think in terms of large quantities or in terms of small quantities.

Capital Requirements

The material consumption percentage, which is a measure of the degree to which manufacture is undertaken, can be used as a basis for estimating the various items of capital investment which will be required. Table A, therefore, shows in the first column material consumption as a percentage of turnover and then, against each, corresponding figures for capital investment under the various

TABLE A

CAPITAL REQUIREMENTS FOR FACTORY ONLY

(Percentage of Annual Turnover at Factory Cost)

Material Consumption	Stock and Work in Progress	Value of Plant and Equipment	Value of Buildings and Land	Total Capital
30	20	60	60	140
40	25	45	50	120
50	30	30	40	100
60	35	15	30	80
70	40	Negligible	20	60

different headings. Actual figures are difficult to obtain and vary very considerably, but the figures in the Table may be taken as a reasonable guide in light engineering. Where it is proposed to establish a new factory, if those responsible could obtain figures of this description from other similar factories, or from factories already existing in their own group, they would find the information extremely valuable.

The information is also very useful to an established concern. For instance, as soon as a factory manager asks for more plant, he should be required to state what effect it will have on the material consumption percentage. The usual justification put forward is that it will save labour or produce a larger output from existing labour, but this often leads to disappointing results.

The first item of capital investment shown is stock and work in progress. Under normal conditions it may be taken that one can hardly expect to be free from production hold-ups unless, on the average, four months' requirements can be carried in stock. The additional amount represented by material in progress will depend on the rate of production. A figure for this can be arrived at in an existing factory, but in a new venture it is not safe to take it at less than three times the longest operation sequence. To take a simple case: suppose in the production of a single article the slowest component takes two weeks to produce and to incorporate in the complete assembly; assuming that the sequence of operations is followed through without interruption, an allowance of six weeks' supply of material in progress for this item should be made.

As the material progresses through the factory, its value increases by virtue of the work expended on it. The value of material in progress should therefore be taken as the mean between the value as raw material and the value as a finished product. Thus, where the raw material value is 50 per cent of the factory cost, the value of the material in progress would be taken as 75 per cent and therefore six weeks' requirements would be equal in value to nine weeks' requirements in raw material. This produces the equivalent of a total of, say, six months' material, but, in addition to this, allowance must be made for slow-moving stock and the desirability of being able to buy ahead in certain materials. Seven to eight months' stock, or a figure equal to about 60 per cent of the corresponding material consumption percentage, is therefore not too much. Of course, this figure will vary with economic conditions and very much so with the class of product; therefore those in Table A can be taken only as a general guide.

The figures for the value of plant and equipment vary in accordance with the material consumption percentage as indicated by the Table. In this case, again, the actual figures are dependent on the class of work in which the factory is engaged. Those given are based on experience of light engineering.

The question of buildings and site can be regarded as an entirely separate consideration. There are many arguments in favour of renting a factory, especially at the commencement or if the concern is relatively small. If this is decided on, the tenancy agreement may be regarded as equivalent to an issue of preference shares to the value of the factory and site at about 6 per cent dividend. Whether the factory is to be owned or rented, it is important to have some idea of what its value should be in comparison with the work to be done in it. This amount can also conveniently be expressed as a percentage of the annual turnover with reference to a corresponding figure for the material consumption. Clearly, the turnover from a factory of a given size engaged only on assembly work must be considerably higher than the same factory making its own component parts. In addition, the construction of the assembly factory can be cheaper because there is no need to provide for heavy floor loads, expensive power wiring, etc. This is why emphasis has been laid on the importance of deciding at the outset the degree of manufacture to be undertaken.

Taking the factory only, and assuming that a separate sales organization takes the responsibility for finished stocks, as suggested, it is sufficiently accurate to take the total capital required as the sum for the items Stock and Work in Progress, Plant and Equipment, and Buildings and Land. In the case where the material consumption is 50 per cent of the turnover, the total capital requirements might be expected to be about equal to the annual turnover. If the total capital required compared with the annual turnover is taken as depending on the extent to which manufacture is undertaken, i.e. its relation to the material consumption percentage, then, in order to arrive at their relationship by the same process of reasoning rather than by an attempt to collect actual figures, one might suggest that the ratio of capital to annual turnover ought to vary in proportion to the margin between turnover and the material consumption. It is from this margin that the cost of the capital must be made. Thus, if in the case where the material consumption is 50 per cent, the capital is equal to the annual turnover, it might be expected that the capital required for a factory having a material consumption of 70 per cent should be about 60 per cent of the

turnover because, in the first case, there is 50 per cent of the turnover and, in the second, only 30 per cent out of which to make a profit to pay for the capital. The Table A is, therefore, drawn up on this basis, but with regard to the whole of these figures for capital investment, an important point to bear in mind is that they are given as an indication of what ought to be contemplated in undertaking a new venture. They may be very considerably in excess of the actual figures arrived at if a check is made in a well-established factory. In such a case, if the financial policy over a period of years has been conservative, the actual value of the plant and stock, etc., should be considerably greater than the nominal value as represented by the actual share issue of the company, or the balance sheet.

The liquid capital required depends on the rate at which finished products can be turned into money. Wherever possible, this item should be made the responsibility of the sales organization. If, for instance, it has been possible to arrange the factory as a separate company, it should be allowed to sell its products to the selling company immediately they are finished. Thus, since money spent on wages and overheads during production has already been allowed for, very little extra is needed under this heading. However, whether it is made the responsibility of the factory or not, this item has still to be found. It may be estimated by taking the total factory cost of the product, multiplied by the maximum number expected to be in stock at any one time.

To summarize, therefore, the main considerations involved in setting up a new factory, or in checking up on the progress of an existing one, are as follows—

Draw up a clear expression of fundamental policy, factors involved in this being—

(*a*) Is the business of the organization to which the factory belongs primarily selling or primarily manufacturing?

(*b*) Certainly separate accounts and preferably separate organizations should be maintained for selling and manufacturing.

(*c*) Is the factory designed to make large quantities in small variety or small quantities in large variety?

(*d*) Is it just an assembly shop or, if more than this, to precisely what extent is it to be a real manufacturing concern?

(*e*) From the above, what percentage is the material consumption expected to bear to the turnover?

(*f*) From (*e*) what total capital investment ought to be contemplated?

Chapter II

THE HUMAN FACTOR

From now on it is proposed to say as little as possible about selling and to deal mainly with the problems involved in manufacture. Many of the generalizations made may be applicable to selling activities, but no suggestion is made that this is necessarily so.

It must be realized that the most difficult task is to deal successfully with the human factor. The design of the product, the best methods to adopt for its manufacture, the overcoming of technical and practical difficulties, and all the other problems in connexion with making things are always easier to solve than the one immense problem of organizing a team of individuals to work harmoniously and efficiently together. It will be found also that if only the human factor can be got on to the right footing, many of the other problems will never arise, or, if they do, will be much more easily solved.

To begin with, people must be treated as individuals and not as cogs in a machine. Even the most humble workman resents, consciously or subconsciously, the idea that he is regarded as something to be bought and sold and treated with less consideration than many animals, or with less consideration than the valuable machines which he uses. He will generally react favourably to the idea that he is an individual expected and encouraged to express his individuality in his own sphere, no matter how restricted that sphere may be. The more intelligent or gifted, and therefore the more valuable the employee is, the less does he resemble a cog and the less is he contented to be treated like one. If a mechanical analogy is to be used, it would be better to describe the organization of the employees in the factory as resembling a number of radiating chains in which each link is vital rather than as a collection of gear wheels in which there are many similar cogs.

To Lead or to Follow?

However, to look at the matter for a moment from an inhuman viewpoint, it may be said that in most industries it is possible to adopt either of two policies, both of which will give equal results. The object of raising the point is to draw attention to the fact that a failure to appreciate exactly which policy the company is following may lead to something which is neither one nor the other, and this

will almost certainly give poorer financial results. The two policies in question are—

(*a*) to employ the best men available in adequate numbers and to spend sufficient sums in training other men to keep up the supply, to pay and equip these men accordingly, and then to lead the field in new developments in order to skim the cream off the market, or

(*b*) to employ a minimum of staff of second-rate ability, to keep their equipment and their salaries down to a minimum, and to make no attempt to be first with anything, relying on the fact that lower expenses will make it possible to come in at a later stage with lower prices and thus make a good living without the cream.

It is doubtful whether any manufacturer could be persuaded to state in public that his company is following the second of the above two policies but, nevertheless, many such cases exist and they often pay larger dividends than those following the policy (*a*).

Loyalty of Staff

Whichever it may be, it is very important that the company should command the loyalty of its staff, and this is not primarily a matter of salary levels or working conditions. Of course, there are many different factors which go towards building up this loyalty, but the main consideration is the feeling of security. Once a general feeling of security of employment has been established throughout, a feeling of loyalty to the company will appear in the staff even in the face of bad working conditions and low salaries. To achieve this, it is necessary to follow a steady policy of avoiding staff dismissals. Since, clearly, this cannot be allowed to become an excuse for inefficiency, it means that all departmental managers must be called upon to devote a great deal of care to the selection of staff and to the fitting of individuals to their jobs. No manager can be allowed to rectify his own mistakes by dismissing the victims. The engagement of staff on a temporary basis should be avoided as far as possible but, if it should be necessary, the temporary nature of the appointment should be made perfectly clear at the outset.

Finally, the general manager himself must keep a constant watch on the salaries bill, department by department, not only on account of expense, but to ensure that no departmental manager is building up his staff to an unauthorized and unjustified level so that the time will come when, for reasons of expense, a reduction will have to be made which will imperil the feeling of security throughout the

whole company. It is advisable to lay down the rule that no departmental manager may engage additional staff without the specific permission of the general manager, and this permission should be withheld unless there is every reasonable likelihood that the addition will be permanently justified. Cases do occur where the staff of a company is allowed to grow gradually over a period until the directors, faced with the necessity for cutting expenses, issue a "purge" order to dismiss a certain percentage of the staff without regard to merit or anything else. The purge is carried out and the staff reduced, but immediately the building up process starts all over again and in two or three years' time the same thing happens. Obviously such a deplorable policy results in a complete lack of loyalty among the staff, and, in addition, a very high scale of salaries is necessary before people can be attracted to the company at all.

The Passenger

It is not suggested that members of the staff should never be dismissed; on the contrary, it is not fair to the rest to oblige them to carry one who is not pulling his weight. The manager has a dual duty. On the one hand he must produce articles of which all concerned can feel proud and make a profit in the process, but, on the other, he owes it to the staff and workers to see that they too get a fair share from the proceeds. This cannot be done unless the staff as a whole work efficiently and, therefore, if all attempts to bring a man up to scratch fail, he must go and the others will not be disturbed, because they know full well the reason.

Individual Control

Starting now from the top, it must be stated that the factory should be controlled by a single individual. He, of course, will have to be responsible to a board of directors, but the board must make up their minds that they have to rely on this man to run the factory, and they must do no more than expect him periodically to report to them on general lines the progress which is being made and to listen to any advice they may have to offer, without necessarily following it. The board have only two alternatives—either let the man run the factory as he thinks fit or, if this does not produce satisfactory results, replace the man.

Any form of dual control cannot be expected to result in the same efficiency, except in those rare instances where two men are able to work in really close harmony.

The sort of predicament which arises is where the general manager of a factory retires and the board find they have two people who have hitherto worked on the same level in the organization and who have, as it were, an equal right to promotion to the vacant position. For instance, there may be a works manager who has not been concerned with and has little knowledge of the accountancy side of the business, and an accountant who has no practical knowledge of works matters. The Board might well feel that the only thing they can do is to place these two people in dual control of the factory, but they would probably find it better to avoid this if at all possible.

The man at the top must make it his business to know really well the group of men who form his immediate links in the number of chains which radiate from him, and to have constant and regular contact with them. In other words, he must always know what they are doing and what they are capable of doing. As soon as he finds he no longer has time to observe this rule, he has too many people directly responsible to him, and must regroup sections or departments in order to reduce this number. Just as he is in absolute control of the factory as a whole, so he must give each of his lieutenants absolute control of his own section or department, and must encourage them to do the same thing in their turn.

The idea of individual control in each sphere must apply both to the staff and to their practical activities; that is to say, the head of a department must, as far as possible, be allowed and encouraged to take sole responsibility for the activities of that department as well as for the organization of the staff working in it.

Fitting the Man to the Job

All executives in charge of staff should learn to fit their subordinates to their jobs. It must be realized that every individual has his good points and his bad points with reference to any job for which he may be considered. Success follows in proportion to the extent to which each individual can be fitted into the job for which he has a preponderance of good points. It is no use complaining that so and so would be an excellent foreman if only he would learn to keep his coat on, where you find the case of a man who was made a foreman because he was an excellent workman and deserved a reward for valuable service. No matter how good a worker he is or how skilled he is, and no matter how loyal and hard working, if he cannot learn to get other people to work while he stands back for a general view, he will never be a successful foreman. The

machine-shop foreman who is usually to be found with his coat off and covered to the elbows in black grease, wrestling (always successfully) with a machine tool which has come to a standstill, is not the right man in the right job.

The difficulty, of course, is to be able to decide whether a man has it in him to adopt the executive attitude as distinct from the worker's, without trying him out, because, while it is fatally easy to move a man up, it is generally almost impossible to move him back. The ability to assess men without trying them out is therefore an important characteristic of any manager.

At first sight it might well appear hopeless to expect to be able, in the majority of cases, to fit employees exactly into the most suitable job. It must be remembered, too, that individuals tend to make their job suit them if they do not suit the job to begin with. Within reason, this is a help provided sufficient care is taken to avoid putting men into jobs for which they are really fundamentally unsuitable. Every effort should be made to obtain a good fit by arranging the job to suit the man on the assumption that it is better to arrange the job deliberately than to let the man arrange it for himself. In the former case, the fit may not be perfect because the estimate of his abilities and characteristics may be faulty, but, although the alternative might seem preferable because it would encourage the individual to use his own initiative, it is, unfortunately, necessary to guard against the universal human failing of laziness.

Because individuals vary so much and because, therefore, either the management must deliberately fit them to their jobs or, alternatively, the individuals will fit the jobs to suit themselves, it is probably impossible to find anywhere a factory organization strictly according to the textbooks. This, however, does not excuse a haphazard organization. The best way to tackle the problem is to draw up a complete list of all the jobs (or, as the books say, functions) which must be fulfilled, and then to group or segregate these in order to fit them to the individuals available. This consideration is possibly more important in a small factory than in a large one, because in the former case several jobs *must* be done by one individual. The manager of a small factory should therefore always remember that there is no "correct" way to group functions; he must allocate them to the people best able to perform them.

It must be understood, therefore, that when in this book reference is made to functions or departments, it is only to point out that such jobs have to be done by someone, and it must not be inferred that they should necessarily become jobs for separate individuals.

Characteristics of Staff

Something might be said about the characteristics which are desirable in the men chosen to occupy various positions. Of course, the occasions on which such ideal men can be found are rare, although not perhaps so rare as one might think. This difficulty, however, does not detract from the value of a statement of desirable qualities, since this sets the ideal for constant reference as the occasion arises. Having chosen the most suitable man available, it is the duty of those above him to develop those characteristics in which he may be weak, and to adjust the precise work expected of him so far as possible to suit his personality and capabilities.

The general manager of a factory should, above all, have a sound knowledge of the fundamentals of the branch of technology covering the factory's products. For example, if it is an engineering factory he should, above all, be a competent engineer. In order to discharge his duties efficiently he will have to acquire also a sound knowledge of the fundamentals of accountancy and some knowledge of company law, the various laws relating to employment, and other things outside his sphere as an engineer. It is probable, however, that it is easier for a man who has graduated from the technical side of his business to acquire the necessary knowledge of accounts than for an accountant to acquire sufficient knowledge of technical and production matters to be an efficient general manager. The above requirement automatically entails a good education, at any rate in the technical sense.

Next in importance comes the ability to use assistance. This includes not only the ability to delegate responsibility but also to fit men to their jobs, command their loyalty and respect, and get out of them the best of which they are capable.

He must be able to sum up a position from the information given by a number of people, each seeing or knowing a part of the whole story, in such a way as to enable these individuals to appreciate the whole and then to give decisions which are prompt, effective, and unambiguous. After this he must have the personality which can admit a mistake and change a decision, when necessary, without impairing the confidence of those affected. Since his direct dealings will be with the more responsible members of his staff, he must realize that leadership is called for rather than drive, example rather than instruction, and, most of all, a clear display of initiative at every opportunity.

Since he should be the main point of contact between the factory

and the outside world, he must also be able to gain both the respect and co-operation of his suppliers and the friendship and confidence of his customers, whether they be outsiders or employees of another section of his own organization.

Finally, he must be able to report on the running of the factory to his directors, who may be (and preferably are) already fully occupied in other directions, in effective and graphic language so that they can, with the least expenditure of time and trouble, gain a general knowledge and appreciation of the business.

The Works Manager

The works manager, that is, the man responsible for all matters relating to actual production, will have more direct contact with the manual worker. To some extent, therefore, the above characteristics should be reversed. It might almost be said that the difference between the general manager and the works manager is the difference between the major and the sergeant-major. The first requirement in a works manager is that he should know what he is talking about. The effect on workers of a display of lack of practical knowledge on the part of the works manager is out of all proportion to the actual offence, whereas in the case of a general manager, such a slip is by way of being expected as a natural phenomenon in a person of such rank.

The second requirement is that he should be a man who has himself gone through the mill of practical experience so that a genuine knowledge of the workers' viewpoint is ingrained in him. Very few men who have not been through the successive stages of apprentice, workman, foreman, are really capable of discharging efficiently the duties of a works manager. Conversely, it is just the natural ability which enables a man to rise through this arduous school which marks him as the right type. His technical knowledge is of secondary importance as compared with his practical knowledge. If he has technical knowledge, so much the better; he can then cover a wider scope in the organization but, provided he has the essential characteristics, he need have no more technical knowledge than sufficient to make him impervious to the deceptions of the technical staff.

Finally, he must have a directness of approach and impatience of evasion in others which enables him to curb the universal practice of passing the buck. Any man who has allowed himself to get into the habit of constantly referring to the mysterious "they" who have always done something or not done something, as the case may be,

will not do for a works manager, unless he can get completely out of this habit and attack it whenever it appears in other people.

The Foreman

Notwithstanding efficiency systems, scientific management, and all the other aids to work without labour in modern industry, the good foreman still remains the king pin. Without at least a nucleus of really good foremen, no one can expect to run a factory efficiently. Before proceeding to discuss the necessary characteristics in a foreman it might perhaps not be out of place to make a few remarks in regard to the way in which he should be treated by those whose business it is to appoint him. It must first be realized that once a workman has stepped up, he cannot generally step back in the same works. If an old and valued employee is being considered for a foremanship, this factor is really formidable. If he fails, he must go altogether. It is almost analogous to the fairy story in which the unsuccessful suitors are beheaded.

In the second place, it should be remembered that he is only one stage removed from a workman, and therefore he needs sympathetic treatment when he finds difficulties in adjusting himself to being part of the management. In addition, it will be necessary to support him and, unless he has outstanding natural ability, to train him for his job. He cannot become a good foreman overnight. When he makes a mistake the manager must come to his rescue and back him up. The manager, however, must not make the mistake worse by merely confirming it on the principle "my foreman right or wrong," but must exert his ingenuity to find a way round the difficulty created, while indicating quite clearly that he still thinks as much of the foreman as before, and without the slightest suggestion of criticism before a third person either above or below him in rank. He should, by all means, have a chat with the foreman, point out his mistake, and advise him how he could have avoided it, but this should be done out of sight and hearing of other people.

What then are the characteristics to look for in a man who is to be made a foreman? First, will he be able to keep his coat on? Will he be able to stand back and tell a man less competent than himself how to do a job and resist the temptation to push him on one side and do it for him—how can this be found out without making him a foreman? One way is to make him an instructor training new operators. It should be particularly noticed whether he displays the ability to deal with several trainees at once. For

instance, can he, by passing from one to another, keep all of them moving and learning, or does he just collect a crowd round him, most of whom cannot really see what he is doing, while he does a job himself to the accompaniment of an inadequate and boring monologue? If he does not, of his own volition, drop into a happy and effective style in instructing, can he be taught to instruct? That is to say, once the trouble has been taken to show him how to instruct operators, will he keep it up afterwards? Unless the man can convince his manager that he will display this characteristic, it might be better to drop the idea of making him a foreman.

Second in order of importance might be placed loyalty to the company, which is to say he shows that he has the company's interests at heart. The man who never asks for a rise until he has given his manager a good opportunity to give him one unasked and, when he gets it, says nothing because he has got what he expected and what both thought he deserved, is the right sort. The same man will often do little things to stop waste of materials, not because he is thinking of what it represents to the company, but because he just does not like to see something wasted even though it is not his property, or because he has subconsciously come to identify himself so closely with the place that, for the moment, he actually feels it is his property.

Again, if, as may well be the case with a man having a more outstanding character than his mates, he is chosen to voice a grievance, he does it in such a way as to create the impression in the manager's mind that he believes it is only because nobody raised the question before that nothing has been done about it rather than to infer that the manager is the sort of man who never does anything until somebody grouses. Then, if, after the company's position has been explained to him, he sees that the requested line of action cannot be taken, he will appreciate the position and thereafter exert himself to explain the situation to his mates so that they do not feel disgruntled. At the same time the manager will find that he must have a really genuine case, and must work hard to present it or he will find himself the loser in the argument and, if this happens, whatever the outcome of the actual incident, it should be put down as a mark in the man's favour.

Self-discipline and the ability to keep discipline among his men, a tolerant attitude to experts often younger than himself who spend their time telling him how he should do his job, a genuine willingness to co-operate with other foremen and staff instead of a constant

desire to score off the next man, are also essential ingredients. He must be a man who, when faced with a tough proposition, states what action he can think of as a way to deal with it, instead of spending his time putting forward all the reasons why it cannot be done. At the same time he should not fall into the habit of making promises which he cannot fulfil.

Perhaps the most important of all is that indescribable characteristic known as common sense. This includes initiative without hasty action, imperturbability in a crisis, a sense of humour, and a sensitiveness which enables him automatically to take the appropriate attitude towards his various associates.

The Chief Engineer

Next, to deal with technical staff, a start might be made with the chief engineer or designer or chief technician in whatever product is being manufactured. Too often there is a triangular war between the shops, the design office, and the sales section because the technician persists in thinking that theory is more important than practice, while the works manager is equally convinced of the opposite, and the sales manager has no knowledge of and no use for either theory or practice in manufacture. The trouble arises from lack of tolerance and lack of respect for each other's knowledge, but this is probably stabilized by the growth of actual habitual disagreement. The general manager must exert himself to overcome this state of affairs, since it cannot be expected that it will be caused to disappear in any other way. The lack of respect probably arises from insufficient appreciation of the other man's work. The general manager should, therefore, take every opportunity, in conference or otherwise, to bring home to each of these people the difficulties which the others have to overcome in their work. When, for example, there is to be an interview with an important customer to discuss a technical point, it may be worth while to invite the works manager on the grounds that something affecting him may arise. The general manager should then conduct the conversation in such a way as to give the works manager a genuine impression of the importance of the technical matters under discussion, and a corresponding respect for the chief engineer who is able to deal with them. The same thing applies when practical matters are in question. The point which the general manager has to bear in mind is that at the outset he must be very careful to guard against either of these executives getting the feeling that his shortcomings or mistakes are being advertised to the other, and therefore it would

be better to confine such "invitations" to matters of future efforts rather than inquests on past errors.

The thing which distinguishes a chief engineer from an ordinary one is not a superior technical knowledge, but the addition of commercial sense. That is to say, he must have it in his bones that everything he does has to be valued in terms of its practical result. All design is a compromise. To begin with, the happy mean must be struck between the article which will do everything and costs a fortune, and the one which will do enough for the price which people will pay. In many respects the viewpoint of the ideal chief engineer would be frowned on by a really outstanding technician, and certainly so by a scientist. However, it takes all sorts to make a world, and it certainly takes a technical man sufficiently hard boiled always to think "What use is it?" rather than "How wonderful it is!" to make a good chief engineer in a factory. The right man for this job is always looking for honour and glory next week rather than being content in the feeling that one day his great-grandchildren will be proud to claim him as an ancestor. That is why experience in America is so useful to an engineer, so long as he does not become an imitation American, and forgets the really important differences which exist in the ideas of customers on either side of the Atlantic.

In dealing with his staff, the chief engineer has to hold a nice balance between encouraging his men to develop ideas and become inventive, and keeping them from wasting time in directions too far removed from the production of immediate results. To him the human element is neither the most difficult nor the most important problem—except perhaps outside his own department. His main occupation should be a constant study of the factory's products to see how, at each opportunity, he can design something a little better at a little less cost either as compared with his previous efforts or as compared with his competitors' efforts—preferably the former so that the necessity for the latter will not arise.

The Accountant

The difference between a good secretary or accountant and a book-keeper at £5 a week is the difference between a watch-dog and a mere recording angel. The good accountant will constantly analyse and investigate all items of expenditure of any importance, and will not be content just to report the results to the general manager at the required intervals. He must make himself one of the team running the factory and not stand aside as a sort of referee.

Then, in giving his information to the general manager, he must exert himself to be helpful rather than painful. The manager does not want to be told that expenditure on electric power, for example, has gone up 25 per cent. He wants to be told that, although it has gone up this amount, an investigation with the supply company's engineers has shown that the installation of static condensers at a certain capital expenditure costing £x per annum in interest and depreciation, will reduce the bill again by £$(x + y)$.

The worthwhile accountant will have in his mind something concrete in existence for each set of figures in his ledger. To him the packing account is not merely £ *s. d.*, but a record of materials which come into the factory and which he can see, if he takes the trouble, being used on the way out. Often he will, from his fresh angle, see possible savings not occurring to the people constantly on the job. It is as well, however, that he should make his suggestions tactfully and with due diffidence.

In a small factory it is the general manager who will lay down and use the budgetary control referred to later, but the accountant must help him by constantly sifting his figures, and must never present a figure out of line with the budget without, at the same time, giving an explanation and at least *some* suggestion to avoid a repetition and to retrieve the position.

So far as the staff is concerned, especially in the smaller factory, it is convenient to have an accountant who can supervise female staff efficiently, not only because he will have to employ girls in his own department, but because it is useful if he can also take over the typists' pool, the mailing section, and any other "female" departments which may exist.

The Personal Assistant

In most factories there is to be found one of those extraordinary and valuable men who cannot be given any particular description, but are generally referred to as damn good fellows. Accident or design may have cast him in any particular position in the firm, but the wise general manager will find him and put him where he is most valuable—as personal assistant to himself. This man is essentially an individualist. He has no flair for controlling other people—he cannot keep his coat on—but he has a tremendous capacity for work himself and a personality which enables him to get things done.

The ideal man is neither a technician nor a "practical" man, nor, generally speaking, has he much fundamental knowledge of

accounts. He can, however, get the right answers to technical questions when replying to letters from irate customers, who have addressed their letters to the managing director, and give them much more tactfully than would a technician if the letters had been passed over to him. He does not know the precise differences between a capstan and a turret lathe, but he does know that the factory cost of a certain job bears a certain relation to that of another done on the same machine and, therefore, from the output achieved in one case, he can make a good guess at what should be produced in the other. He might not be able to draw up a profit and loss account in the best style, but he has a nose for jobs which must be losing money long before the cost department figures are available.

Such a man, as personal assistant to the general manager, can fulfil fundamentally two functions. On the one hand he can do all those valuable odd jobs which are really outside the scope of the private secretary, and therefore for which a man is essential, and he can act as the liaison between the customer and the factory, in this way ensuring that the general manager gets at first hand all essential information regarding orders, deliveries, progress, and complaints.

In a small factory, especially if it is producing in small variety, he can act as the order department, and if he can also look after despatch he can see to it that the factory does not earn the reputation for never keeping delivery promises. In the larger factory he will collect daily summaries of orders received and deliveries made from the respective sections so that, in any case, he is the man who knows what is to be done, what is being done, and what has been done and will see that, shorn of detail, the general manager has the same knowledge.

Conferences

It has already been said that the general manager should concentrate on knowing really well his immediate subordinates, and have regular and frequent contact with them. The frequency of contact will vary with the individual. If the general manager and the works manager do not meet by intention every day, they will probably have to meet by force of circumstances. They will, therefore, probably find it advisable to have a regular daily discussion at a set time, and both could then make a note of points to be discussed, in readiness. The general manager should avoid sending for the works manager every time something occurs to him or

every time a problem arises, unless it is very urgent. Otherwise the constant coming and going is not only a waste of time, but the interruptions have a bad effect on the works manager's efficiency, to say nothing of his personal feelings. Other staff should be encouraged to take the same view with their subordinates. A general manager's contact with other executives, such as the accountant and chief engineer, will probably not be so frequent except at certain periods or under exceptional circumstances; while he will, of course, see them individually, his contact with them will, in many cases, take place at conferences.

Conferences should be looked upon as a necessary evil and kept down to the minimum. A certain number is unavoidable, but any tendency to exceed the absolute minimum should be severely discouraged. A conference involves taking people away from their jobs for a period. It should not be held outside normal hours in order to avoid this, because that means extra work, and, since it will invariably be in the evening, will take place when those attending are tired and therefore unlikely to be at their best.

The utmost care should be taken to avoid calling to it anyone not really required or, on the other hand, excluding anyone concerned definitely with the matters to be discussed. So far as possible a conference should be confined to a limited agenda restricted both in length and variety of subject-matter, so that all the people present are interested in the whole of the proceedings. Where a discussion of several subjects cannot be avoided, no member of the staff should be asked to attend before his subject comes up or kept present afterwards. This means that the order of the agenda should be drawn up with due regard to the people concerned, so that the coming and going is reduced as much as possible.

The chairman of the conference should notify in good time all who are to be present, letting them know what is to be discussed, and should make every effort to start promptly. The habit which some managers develop of calling a conference for a certain hour and then postponing it several times during the day, ultimately holding it when it is nearly time for everybody to go home, is deplorable.

Once the conference is started, the chairman should exert all his skill to keep the proceedings brief and to the point. He should remember that every minute wasted is multiplied by the number of people present. Whether he realizes it or not, his own prestige will vary in direct ratio to his ability to observe this rule.

Objects and Procedure in Conferences

Works conferences have two main objects: first, to report action taken and proposed, for approval, and, second, to offer suggestions and advice for decision. The person responsible for the matter under discussion should take the chair. If the matter has previously been the subject of a conference, he would naturally start by going through the minutes of the previous meeting. As each item is dealt with, he would call first for reports from the individuals who, according to the previous minutes, were to take certain actions and from others for information regarding expected events of which they should have knowledge. Some items will be disposed of when this has been done and recorded. In other cases a discussion involving a decision will be called for. The chairman will then obtain the views and ideas of the members. He should, where the importance of the matter warrants it, then sum up the observations made. He will thus get his own ideas straight, give the opportunity to any member who may wish to amend or correct a statement, and, if he is clever enough, make all present aware of the whole story, whereas previously each may only have known one particular part. At the conclusion of this summing up he should give his decision; anything in the way of a vote is absolutely taboo.

The reason why the dictatorial method is advocated is because there is never a "right" way to do anything. The man who maintains that there is, is always wrong. If six people meet to consider a problem, they will very likely advance six different solutions and, if they are all intelligent, competent people, there may very likely be little to choose between the six ideas. The vital requirement is that the man in charge of the conference should pick out one idea and see that it is put into effect with promptitude and determination. In the end, events may prove that it was not actually the best idea, but at least something has been achieved, whereas if the decision had not been made the members of the conference might still be arguing.

The minutes of the meeting should be brief and contain only the essentials of the discussion. A verbatim report is quite unnecessary and, in fact, undesirable. Consequently, unless she is skilled in the job, the presence of a stenographer to record the proceedings is a waste of her time. One person present should be detailed to take notes and afterwards dictate the minutes. Actually, since he is the one person sure to be concerned with the whole proceedings, it is strongly recommended that the chairman should himself undertake

this job. This will have the additional advantage of ensuring that he has really made himself thoroughly conversant with the subject. The minutes should be circulated as quickly as possible after the meeting, since any delay may destroy the value of the conference.

The atmosphere created at the conference is very important. It should be sufficiently serious to discourage any tendency to waste time, while sufficiently informal to encourage those people who may be naturally diffident.

Chapter III

DESIGN AND DEVELOPMENT

All production should start in the design and drawing offices. These two functions may be combined in the same department in the small factory, but in a larger one, and also depending on the technical complexity of the product, they may be separated. Even the smallest factory should avoid the mistake of trying to work without drawings. Surely all owners of small factories hope to see them grow in the course of time, and if they start off on hit and miss principles they will sooner or later have an immense and totally unnecessary problem to face in getting the business on to a proper basis.

The departments concerned are the domain of the chief engineer or equivalent in other branches of technology. The desirable characteristics of such a man have already been dealt with. Except in the very small factory, it is preferable that a distinction should be made between engineering or design and draughting. Using, for the sake of simplicity, the case of the engineering factory, this means that the actual designing of the product should be done by an engineer assisted by draughtsmen who make the necessary drawings and, depending on their capabilities, attend to minor design points. The engineer, however, should be the one held responsible for the whole job. In some factories engaged in engineering there is a tendency to confine the engineers to the technical design and to make the mechanical design the responsibility of the drawing office. This division is undesirable. It would be better to train and to employ engineers capable of dealing with the whole of the design problems involved, and always to regard the drawing office as subsidiary to the design office—not as a parallel organization. A point to be borne in mind is that an engineer should be a man who has had a better education and training than a draughtsman, and it is inefficient to expect the former to waste time making drawings and the latter to struggle with empirical formulae without a knowledge of their derivation and without facility in the use of a slide rule.

The exact system adopted to produce the necessary information from the engineer and to make it available to the sections requiring it will depend on so many factors that there is not much point in suggesting one. There are, however, certain definite requirements which must be accommodated in the system.

These are—

(1) The engineer must convey in writing to the draughtsman the required information in regard to the design.

(2) The drawing office must produce whatever layouts or other preliminary drawings may be necessary to enable the final design to be settled by the engineer.

(3) The drawing office then produce—

(*a*) complete working drawings,
(*b*) a parts list,
(*c*) a schedule of materials required,
(*d*) specifications providing any information which cannot conveniently be given on a drawing. This item may, in certain instances, go direct from the engineer to the people concerned.

(4) All information thus prepared must be indexed for permanent record.

It is advisable that standard forms should be used in each case, so far as practicable. In this way there is a safeguard against omissions and errors. If, for instance, the engineer has to give his instructions to the drawing office by filling up a standard form, he will not have to waste time trying to think whether he has forgotten something, and the form will be arranged to keep him to a method of working out the required figures which is efficient and readily understood by his colleagues, who can therefore check or, should the occasion arise, complete a half-finished job.

Initial Planning

A close connexion between design, drawing, and *planning* is highly desirable. If it is close enough it eliminates those annoying and too frequent occasions when instructions are issued to produce something which cannot be made, and the innumerable occasions when production could be facilitated if the design had been a little different. Except perhaps in very large factories it is, therefore, a good idea to get the planning done by the engineer and the draughtsmen, who, between them, have to produce the design and the working drawings. It is probably better to have tool drawings dealt with separately, but all drawings required for equipment as distinct from tools should be done by the draughtsman who also makes the working drawings for the product. In other words, instead of making one set of people responsible for the design of the product and another for the methods by which it is to be made,

make one set of people under one man responsible for both. Apart from anything else, this arrangement creates far more interest in the product and this alone is a most valuable consideration.

The word "planning" is used in a variety of senses, and it should therefore be stated that here it is intended to cover the compilation of the processes to be followed, their sequence, and the methods to be adopted for each process. The whole is generally illustrated by a layout drawing for the part or parts of the factory to be used, and accompanied by drawings or other particulars of the equipment which is to be made or purchased.

Of course, the particular factory people concerned should be consulted while planning is in progress, and the design of the product considered final only when the planning is complete. In this way, those who have to make the job have the opportunity to make suggestions in good time. As soon as the final details in planning are being dealt with, contact has to be made with the production control section. This is necessary because often the precise process to be followed must depend on the facilities which will be available at the time required. Actually this contact is probably of more importance to the tool designer than to the planner, as will be seen later.

Development of New Designs

To deal now with the design itself as distinct from the mechanism of translating design into actuality, it is necessary first to say something about development. Many manufacturers now have development laboratories. The arrangement generally found to be most satisfactory is to arrange the development department or laboratory to be within the factory itself and under the control of the chief engineer. Anything in the way of research work, as distinct from development of a particular product within relatively confined limits, should be done in a research laboratory which can quite conveniently be separated from the factory. In order to justify a research laboratory of reasonable dimensions, it can be arranged to serve several factories in the same group or to serve separately owned factories which have formed a research association for their mutual benefit.

The development engineer may be regarded as the man who turns the discoveries of the research worker to practical use. It is better to keep the development staff separate from the design and drawing office staffs. The latter should not be allowed to waste their time in matters which are still in the experimental stage. The

development department should also have its own workshop even though it is only possible to have a very small one. The aim should be to keep experimental work out of the factory.

At the outset, therefore, the chief engineer will deal with the development engineer, and do little more than keep the latter's enthusiasm within reasonable limits. Where sufficient money can be spared, it is recommended that the development section should be allowed and encouraged to produce something which will give the ideal performance, even though it is commercially too expensive. When such a sample has been produced and tested, it then becomes a matter of determining just where to compromise between what is known to give the ideal performance and what is considered to be a practical proposition. This latter stage may well be made the point at which the job is handed over to the design engineer and the drawing office.

Functional Design

Of recent years far more attention has been paid to the appearance of articles of utility, so that they are pleasing to look at as well as efficient in use. In fact, strict attention to details which were previously considered to have no effect on the efficiency or utility of the article has led to what is known as "functional design."

A good functional design is one in which all the various parts are carefully designed for maximum efficiency, no part, however small, being neglected, and the whole being combined together with the utmost simplicity. The net result is usually very pleasing in appearance, although, strictly speaking, nothing has been done for the sake of appearance. The word "streamlined" is often used —quite inappropriately—and yet there is an element of reason in it, since pleasing and useful curves have often been substituted for objectionable and quite unnecessary angularities. Several parts may be combined into one part and the resulting homogeneity creates a pleasing appearance. This is often only made possible by the use of a new material, such as one of the plastics, or by a relatively new process, such as pressure die-casting, or the various machine-welding processes. For instance, modern tool design and developments in steel enable the complete side of a saloon car to be formed in one piece. Although the various curves which are incorporated are designed primarily to reduce air resistance in travel (true streamlining) and to produce a strong member from a thin sheet of steel, the result is attractive to look at.

Industrial Designer

This trend in design has led to the employment of the industrial designer. This is a man (or woman) who is primarily an artist or architect and who, therefore, has a natural ability and some training in combining masses and shapes to produce an attractive result. He generally knows little of the technicalities of the product in question, but can give the external appearance of that product that indefinable air of distinction which is now so essential. Consequently, the final product must necessarily be the result of the combined efforts of the industrial designer who looks after the outside and the factory designer who looks after the inside.

When such an arrangement is first introduced into a factory, and unless the matter is dealt with very tactfully, a feeling of violent resentment on the part of the factory staff to the outsider immediately appears. This attitude is natural enough when considered dispassionately. After all, the factory designer has probably been responsible for the designs of the various products for many years, and cannot be expected to like the idea of an outsider being brought in to teach him something. Then, of course, he is quick to point out that any fool can draw a pretty outside if he is not to be responsible for making it contain an efficient inside.

The whole matter is made much worse by a deplorable and inexcusable tendency to let the industrial designer take the whole credit for the final result. To advertise a new design of vacuum cleaner, for instance, as the work of XYZ, the famous industrial designer, is an obvious lie and a gross injustice to the engineers who have been responsible for its working parts—especially as the industrial designer's ideas on appearance have probably increased the difficulties of their task. Both the factory management and the industrial designer himself should realize that to ensure that co-operation, without which success is unlikely, this point must be dealt with at the outset. It must be made clear that everyone will ultimately regard the product as the joint result of the two designers, and no advertisement or other publicity will attempt to suggest otherwise. In America this difficulty has been overcome by describing an article as having been "styled" by XYZ.

Provided it is put to him the right way, the factory designer will appreciate the soundness of the reasoning that the *artist* is bound to know more about appearance, and provided the industrial designer will sympathize with the factory designer's difficulties in rearranging and altering essential parts to suit the former's ideas

of appearance, and will always adopt the suggestive attitude rather than the dictatorial, a spirit should be established which will lead to very valuable results. It is easy to say that such conduct should not be required, but one is dealing with human beings and must take them as they are and not as one would like them to be.

A suitable working basis for the team will depend on the type of product being designed. In the case of a product where the external shape must necessarily tend to be complicated because of the mechanism involved, such as, for example, a vacuum cleaner or a lawn mower, the factory designer would start first and the industrial designer would do his part on the outside afterwards. He should, however, have the factory man at his elbow all the time so that, as soon as the latter sees he is having difficulty over a particular protuberance, he can say right away whether it is possible to alter his part to reduce or eliminate that protuberance.

Where the article is such that the outside can quite well be a simple cube or a series of cubes, such as would be the case with a cooker or radio gramophone, it might be better to let the industrial designer start by making several groups of perspective drawings, each group comprising variations on a particular theme. When the factory man has gone over these drawings and the two have, between them, modified or discarded where necessary to ensure that the remaining pictures do show something which it is possible to make, the sales people can be invited to assist in making a choice.

Competitive Products

Another series of design problems is created by the necessity for what might be described as "watching the other fellow." No designer can afford to neglect a study of all the competitive designs on the market, and it is deciding just how far to go in "copying" which calls for the commercial sense previously referred to. Plagiarism is bad business, but a mere alteration of appearance is not sufficient. The first thing the designer must do is to study and test the competitive design until he is satisfied that he really understands the reason for every part of it. Cases are not unknown in which an original design, due to a last-minute alteration, contained a hole or other feature which was quite unnecessary, but where conditions at the time made the elimination of it not worth while. A later copyist, while taking care to alter appearances, has copied the hole just because he could not understand why it was there, and dared not omit it in case it served some useful purpose.

In this connexion, also, problems are created by the fashions

or tastes existing in different countries or in different parts of the same country. To deal first with the difference between countries, the designer must bear in mind that ideas gathered from an examination of a foreign product or a foreign factory are liable to be dangerous. For instance, a popular source of inspiration to British engineers is America, and it is a safe rule to say that nothing of American design is suitable as it stands either for manufacture or for sale in this country. It is probably unsuitable for manufacture because production in America is on a much larger scale, and unsuitable for sale because the tastes and requirements of the American buyer are different from those of the buyer in this country.

American Designs

In passing, reference might be made to the idea which sometimes bites British manufacturers and causes them to link up with an American concern with a view to making an exact copy of the American product. The usual procedure which is proposed is first to sell the complete American article in order to establish a market, then to import component parts and assemble here, and finally to make the whole product in this country. In few instances can such a scheme be expected to succeed.

To begin with, it is unlikely that the American article can be sold here exactly as delivered. Even if the only alteration required is that necessary to make, say, an electrical appliance suitable for the popular British 230 volts instead of the American 110 volts, it may be quite enough to take the gilt off the gingerbread. The second stage is guaranteed to produce a fine crop of difficulties. The cost of getting the various components over here will probably be found to be very nearly equal to the cost of the whole article, so that whatever is spent on assembly is a dead loss. Then, especially if the article is one subject to seasonal sales or which dates quickly, the delay factor will come in. The American seasons coincide with ours and, therefore, if an attempt is made to assemble the current model, it will be found that the Americans, being probably behind programme at the beginning, cannot ship the agreed parts until later on in their manufacturing season so that, by the time they arrive, it is already too late for assembly in time for the selling season in this country. Unfortunately, it is just the articles which are subject to seasonal sales in which there is also a tendency to change design frequently. If, therefore, in order to overcome the above problem, the British manufacturer decides to work to a year-old design, he will then find he is losing ground in competition

with those who have imported the complete article, and have therefore got the up-to-date model from an American competitor.

Further, having resigned himself to the losses involved in the first two stages, in order to arrive at the third, the British manufacturer finds himself in a very sad state. The scale of American production is probably vast compared with that contemplated here, at any rate to begin with, and therefore considerable design modifications are necessary to suit the smaller scale production. Then the time and money which have probably been spent in sending people over to the U.S.A. to study manufacturing methods are found to be largely wasted because, since the methods depend almost entirely on the scale of production and on the precise design, few of them are applicable, although, of course, the knowledge of them is valuable.

Development by Stages

Development can cost large sums of money for very small results unless carried out on well-regulated lines, and the design of the final product may well be the making or ruination of the whole concern. The following basic rules should therefore be observed.

At the outset a statement should be drawn up specifying as closely as possible the article which is required and if, at this stage, some indication of the quantity can be given, so much the better. If it is something new, a précis of the research work which has led up to it and a bibliography of research work on the same subject should be made available. It is quite an efficient arrangement if the development engineer himself draws up the bibliography because, in this way, he makes himself familiar with the work which has been done on the subject.

If it is to be a new variety of a product already on the market, samples of several makes which are considered to be good should be obtained and tested. It should be noted that careful tests often reveal surprising discrepancies in performance and life between samples previously considered to be of equal merit. If the article in question is to be the practical result of an invention offered to the company, it should be treated on the same lines as a new product and as if it had been invented by one of the company's staff.

A report is then required tabulating the results obtained from the tests on competitive samples, together with a description of their salient points, and especially any points which play an important part in producing desirable features in performance. At the same time another report is required from the patents department or from the company's patent agent covering all patents in respect

of the articles tested, and any other patents found which are likely to be of interest. At this stage a very extensive search or an examination of citations is probably not worth the expense.

Based on the above information and on his own preliminary investigations, the development engineer should then draw up a report stating—

(*a*) the lines on which he proposes to proceed;
(*b*) the major patent difficulties;
(*c*) any recommendations regarding suggested patent licence or licences which might be feasible and worth while;
(*d*) any further research work which is required to assist him;
(*e*) an estimate of the time required to produce the "A" model.

This report will be studied by the chief engineer and amplified in discussions between him and the development engineer. At this stage, unless the job is of extraordinary importance or likely to involve an unusually heavy expenditure, no other individuals or departments need be drawn into the discussion. Provided, therefore, the report does not show that further progress is impossible or undesirable, the development engineer will proceed with the construction of the "A" model. The "A" model or models are required only to try out those parts of the article which represent new ideas. Consequently they will be largely lash-up models, possibly bearing no resemblance to what is ultimately intended. Several models, differing in order to enable a decision to be made between suggested alternatives, will probably be made, but if so, their variation in construction must be carefully planned so that a scientific series of tests can be applied. The basic rule in this connexion is that, in a series of tests, only one feature must be altered at a time. Otherwise a variation in performance cannot definitely be ascribed to one particular alteration or addition. The models must, therefore, be constructed in such a way as to allow for tests to be made covering all the required combinations of different features, each step differing from the previous one in only one particular.

Emphasis must be made on the importance of theoretical calculation at this stage. Particularly if the article is small and, therefore, no tremendous amount of work or material is involved in making models, there is a great temptation to try hit and miss methods to arrive at something which could, with some thought, be calculated. Even though it appears probable that no exact calculation can be made, a calculation as near as may be will at

least reduce the range over which experiment is required. There is a particular type of individual who is ingenious, clever with his fingers, and often quite inventive. He has, however, no considerable technical knowledge and is too impatient to use the knowledge of others. Such a man is not a suitable development engineer. The ideal type is a man who is one stage removed in the practical direction from a research engineer or physicist. That is to say, he has first and foremost a sound technical education, he displays a proper regard for calculation as opposed to guesswork, he has had some training in experimenting in a logical way, and if he can also use his hands, so much the better.

In the construction of "A" models there should be no hesitation in using substitutes or ready-made components for those parts which do not affect the new ideas being tried out. For instance, parts taken from a competitive model may be used if it is intended in the end to use something similar to these parts. In other directions, extensive use can be made of wood, plastics, low melting point alloys, etc., in order to reduce the work which would be entailed in making these parts from the materials finally intended. In doing this, however, one important consideration must be borne in mind. Any part which is new and which, therefore, it is the object of "A" model to try out, must be made as it is proposed to be in the final design and tested under conditions which reproduce as nearly as possible the conditions of actual use. For example, if it is proposed to use die-cast gears in a gear-box and the object of the "A" model is not to try out some new principle in gear-boxes but to try out die-cast gears, then obviously the "A" model gears must be die castings, even though this means spending money on tools which may be scrapped if the idea is not successful. On the other hand, since it is the gears which are in question, the gear-box may be made of any material and by any method, provided it has no effect on the performance of the gears themselves when they are undergoing test.

In testing the "A" model it may be found impossible to reproduce conditions resembling those which it will meet in actual service, but this does not matter provided the artificial tests are arranged to duplicate actual conditions so far as the features undergoing test are concerned. For instance, if a thermostatically controlled electric iron is being developed, there is no need to bother about a handle on the "A" model, and therefore practical ironing tests cannot be undertaken. This does not mean to say that tests conducted with the soleplate resting on a retort stand

are conclusive or satisfactory. Some substitute for the effect produced when the soleplate is brought into contact with damp cloth in actual use is necessary. Again, if it is proposed to use a pressed-steel shoe for the top of the iron, it is most unlikely that tools would be put in hand for such a pressing until a later stage. Tests conducted with the top open, however, will not do because the behaviour of the thermostat under such conditions would be quite different from its behaviour when it is closed in. Therefore a shoe must be made for the "A" model by some method such as beating out from a copper sheet or, preferably, a steel sheet because, although the latter involves much more work, the different thermal properties of the former might affect the test result.

Having concluded his work on the "A" stage, the development engineer will draw up a report and submit it to the chief engineer. Often, however, it will be found necessary to remind him that he has exceeded the time he estimated and to instruct him to close down as soon as he can finalize the tests on the models he has so far produced. This is due to the fact that, as soon as tests on a model begin to show results, other ideas occur to the engineer, and he is immediately tempted to construct more models or to alter the ones he has already made to try out these ideas and so on *ad infinitum.* Force of economic circumstances, however, make it necessary to call a halt, even though the engineer feels convinced that his latest idea will be much better if only he can be given a little more time to try it out.

At this stage other people should be brought into the discussion. The works side should be given the opportunity to make comments from their angle, and the planning and tooling engineers from theirs. Also it might well be advisable to draw in the buyer in case he may be able to supply some useful preliminary information in regard to materials.

Unless, however, it is the appearance of an article which is under review, the sales people should definitely be excluded. It should be realized that they have no training in or knowledge of what is required, but, on the other hand, they are likely to express views with considerable force and tenacity. Also, by the ordinary process of development, the final article may bear not the slightest resemblance to the "A" model, at any rate in a salesman's eyes, and this will cause quite unnecessary heart-burnings. Unless, therefore, one is extremely fortunate in one's sales staff, it is advisable to tell them nothing and show them nothing until finality is reached, so far as the technicalities of the product are concerned.

The "B" Stage

From the "A" model report and the subsequent discussions referred to above, instructions can be drawn up to cover the production of the "B" model. The object of these instructions should be to confine the job to definite lines decided on from the "A" model experience. Unless it is in a very minor part, nothing experimental should be incorporated in the "B" model. If the review of the "A" model indicates that further experiment is necessary, the "A" stage should be prolonged and a revised "A" model and report provided in due course, a time limit being again fixed. The instructions covering the construction of the "B" model should include a statement in regard to the numbers to be manufactured and the rate of production desired. The actual final design, as well as the tools and the shop layout, very largely depend upon these figures.

The "B" model should represent the final job except that where it is possible without affecting the performance or appearance to avoid tool making, components may be hand-made. If the appearance of the article is very important, "B" stage "appearance" models may be made in parallel with complete working models in order to show alternative external designs.

Depending on the product, coloured perspective sketches may be sufficient. But here it must be emphasized that the sketches must be prepared by a man or woman really capable of drawing in perspective. The isometric projection efforts of a draughtsman are quite inadequate.

Apart from the normal tests to confirm that the performance is what was expected from the results obtained at the "A" stage, the most important piece of information to be derived from the testing of the "B" stage models is the life of the article in use. Sufficient samples to give conclusive results must be put on life test against competitive samples already well established on the market, and shown to be the best by the preliminary tests previously referred to. Testing against competitive models is stressed because it is generally necessary to adopt means to accelerate life tests, and it may be impossible thus to obtain results identical with those which will follow in actual use. Consider, for instance, a continuous test on an article such as a vacuum cleaner which, in actual use, will be in operation generally for short periods with relatively long rest periods in between. When running continuously a steady maximum temperature will be reached, while in actual use it may never run long enough to reach this temperature. On the other hand the

standstill periods in service will produce corrosion, drying of lubricant, settling of dust, and other effects quite impossible to reproduce in a continuous life test. Fortunately, experience shows that more often than not the life in actual use is longer than that indicated by continuous life tests in the factory.

As previously suggested, the "B" model might well be handled by the design staff as distinct from the development staff, the latter handing over the job at the conclusion of the "A" stage. In any case the report on the "B" model must be accompanied by a more detailed investigation into the patent situation. By this time the design staff will know fairly exactly what they want to do, and therefore it will be possible to say whether anything proposed is likely to be an infringement or whether it can be made the subject of a patent application.

At the conferences which are called to review the "B" model and its report, the sales staff should be represented as well as all departments concerned with manufacture. Also, a point not to be overlooked, the packing and transport people should be given the opportunity to see and comment on what they will have to handle and to make arrangements accordingly. If the "B" stage model is handled by the design staff, and if the suggestion that the same people should do the planning is adopted, the job will be largely planned by the time the models have been tested.

The "C" Stage

Following approval of the "B" model and the report on it, work can proceed on the tools, jigs, and fixtures, and on the shop layout. As the tools become available trial components can be made and from these "C" models constructed. The "C" models are simply pre-production models made up primarily to test out the tools and manufacturing processes. Once complete, and while any alterations in the tools or layout which have been found necessary are being put into effect, the "C" models can be released to the sales staff for demonstration purposes.

The development procedure thus outlined may perhaps be considered elaborate, but it comprises no more than the essential work, and while in any particular case a manufacturer attempting to short-circuit it might be successful, the chances are that in the end he will not arrive at such a satisfactory product and, in the process, will spend far more money and time than would have been the case if he had made up his mind at the outset to tackle the job in a sensible manner.

Chapter IV

THE DRAWING OFFICE

The precise arrangement of the drawing office and the limitations set to the functions it is expected to perform depend on the types and varieties of products, their technical complexity and the degree of mass production, but there are certain general principles which have an almost universal application. The following applies to a factory producing a limited variety of products, say of the order of five distinctly different products per 100 manual workers in reasonable quantities, that is, between 100 and 5000 of each type per annum. Of course, there may be several varieties of each product. This may perhaps be regarded as the average factory, at any rate in engineering, the extremes being, on the one hand, the jobbing shop doing a large variety of different products in very small quantities, for instance a factory devoted entirely to tool-making, and, on the other hand, a single product factory such as one making, say, nothing but vacuum cleaners. The manager of any particular factory which may approach one or other of these extremes must decide for himself to what extent these suggestions are useful to him and to what extent certain of them may be eliminated or others elaborated.

Drawing Sizes

All drawings should be made in one or other of a number of standard sizes. These should be chosen to enable the existing standard sizes of paper to be used without wastage. Recommended sizes are given in B.S.S. 308. Preferably working drawings (i.e. all drawings other than layouts) should be made on sheets cut to standard sizes and having already printed on them information which appears on all drawings, such as the company's name, the symbol indicating the drawing size, statements in regard to standard limits, etc., and divided off spaces for amendment particulars. Figure 1 shows such a drawing sheet. If the printed information is on the reverse side it will show more clearly on the print and, in the case of tracing cloth, it will avoid trouble when rubbing out is necessary.

Drawing Numbers

All drawings must be numbered serially and a single index kept by the D.O. clerk unless the D.O. is too small to warrant a

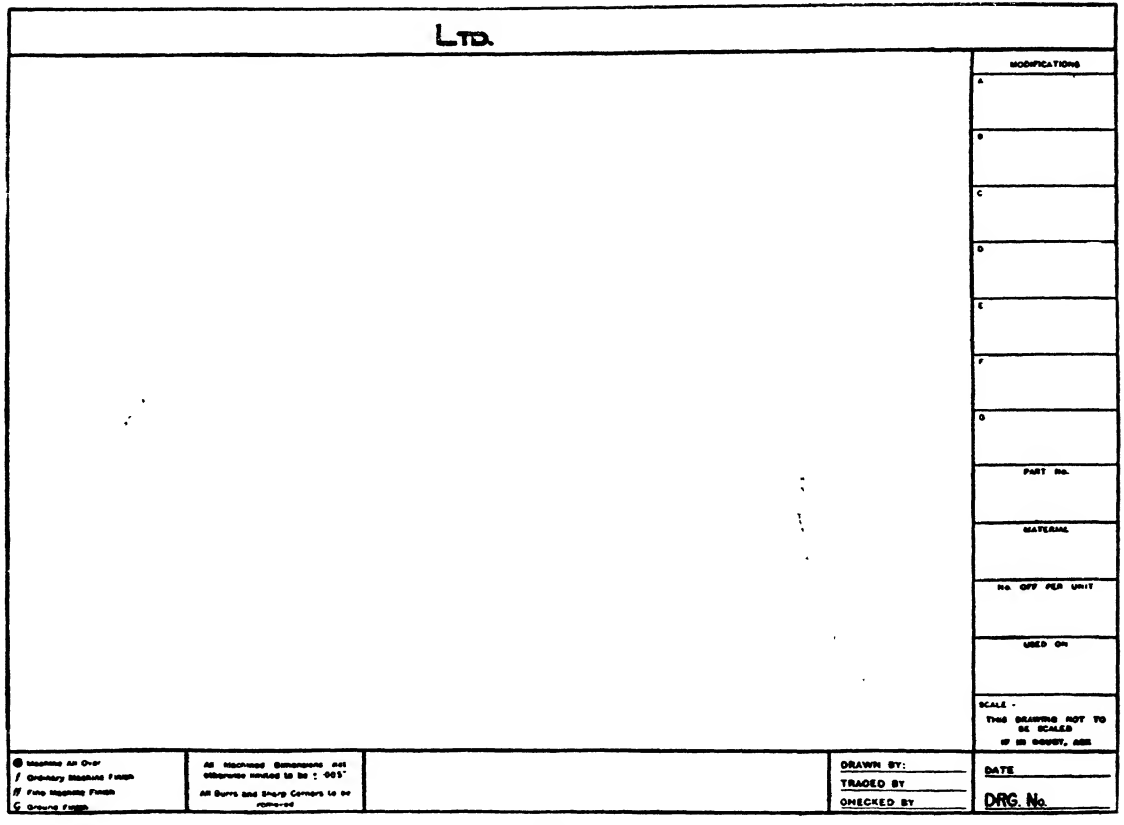

LTD.
MODIFICATIONS
A
B
C
D
E
F
G
PART No.
MATERIAL
No. OFF PER UNIT
USED ON
SCALE -
THIS DRAWING NOT TO BE SCALED
All Machined Dimensions are Otherwise limited to be ± .005"
All Burrs and Sharp Corners to be removed
DRAWN BY:
TRACED BY
CHECKED BY
DATE
DRG. No.

FIG. 1

clerk, in which case it should be kept by the leading draughtsman. As a draughtsman completes a drawing, he should obtain a number from the man keeping the index book, who should make sure to enter the title of the drawing in the book. The greatest care must be exercised to ensure that no two drawings exist having the same number.

Customers' Drawings

Where the customer supplies drawings showing his requirements it is usually well worth while to have these copied, making the necessary adjustments to bring them into line with the standard practice ruling in the factory. The saving in draughtsmen's time consequent upon issuing customers' drawings direct to the shops is more than offset by the errors which occur due to the strangeness of the drawings. There are other reasons, such as the difficulty of getting extra copies and that re-drawing often brings to light mistakes in the originals. The fact that some other factory has already worked to the drawings is no guarantee whatever that they are free from errors.

Sketches

If it is the practice to issue sketches to save time or for other purposes, these also should be done on a standard size of paper and bear a distinguishing symbol (Sk. is obvious) and a serial number. Care should be taken to guard against the possibility of a sketch being issued bearing the same number as a drawing.

Tracings and Prints

Tracings on linen are very much more permanent than original drawings on paper, but are expensive to produce. On the average it probably costs from a third to a half as much to produce a tracing as to produce the original drawing. An arrangement which is reasonably satisfactory is to make prints on sensitized tracing cloth from paper drawings and to use these as originals. Unfortunately, it has not so far been possible to render this process entirely satisfactory, as often the cloth print is not clear enough and requires considerable touching up.

Various processes exist for producing prints having a dark line on a white background and these are, generally speaking, an improvement over the old-fashioned blueprint except that they show dirt more easily. However, the contention that a white print is more liable to become indecipherable in use in the shops is probably

not justified. White prints are certainly much more attractive to send out to customers.

Issue and Recall of Prints

The departments to which prints are issued are preferably entered on the original drawing. The names of the main departments with blank spaces where the draughtsman may enter the names of others as the occasion arises may be printed on the sheets. In any case, the D.O. clerk must keep a record of all prints issued and obtain a signature for each one from the person responsible for its custody.

As soon as it becomes necessary to amend a drawing the draughtsman must, after making the alteration on the original, enter as briefly as possible a description of the alteration in the first vacant revision space and give the number of the revision and the date. He then hands the original to the D.O. clerk, who obtains the required number of prints off it and re-issues them. The clerk must do everything possible to get back the previous prints issued, in exchange for the new ones, and destroy them. There will often be cases where the prints cannot be found. When this happens a system whereby the fact can be put on record in the guilty department is a valuable safeguard against the possibility of an operator working to an out-of-date print. If, in an emergency, a draughtsman goes round and makes an alteration on an actual print, he must initial it and take the responsibility for seeing that the original is brought into line as soon as possible and new prints are issued.

The issue of prints to operators must be controlled as strictly as the issue of materials, not because of their value but to guard against the danger of an operator working to an out-of-date print. A satisfactory arrangement is to store the drawings in the time-booking office and to issue them with the "C" card (page 71); the "B" card acts as a receipt for the drawing. The booking clerk should not allow the operator to book off the job unless he hands in the drawing or, if he is proceeding with another batch to the drawing, unless he produces it to show that he still has it. In the latter case the foreman must check that the print the operator has is up to date by comparing the latest revision number with the information on the "A" card.

It is probably not necessary to issue prints to the production control section, but they must be notified promptly if any revisions are made, so that they can amend their records to ensure that no further "A" cards are issued calling for an out-of-date print. This

Issue No.							Part List No.:	Sheet No.: Of.
Date								

Item No.	Part No.	Drwg. No.	Description	No. Off.	Size	Material	Remarks

FIG. 2

means that the D.O. clerk must promptly amend all copies of the parts list on which the drawing appears. This is a complicated matter, because it necessitates an index from which he can find out all parts lists on which any particular drawing appears. Consequently, where a number of different products are being made in several variations, so that this index would become formidable, it is common to omit any reference to the latest revision symbol on the "A" card and put the onus on to the person issuing the prints to see that the latest print is given to the operator.

Parts List

The essential feature of the parts list drawn up by the D.O. is that it should show every part without exception required to make one article. Its primary purpose is to ensure that every item which is required to make the article will be produced or purchased. With this in mind it is probably better not to complicate the parts list by incorporating in it information which is not strictly necessary to achieve this purpose, such as particulars regarding the planning of the job or the rate fixer's data. Like all other forms, the greater the simplicity the more likely is it to be properly used. If the parts list contains dozens of columns to cover all sorts of information, it will most probably be found that the staff will slip into the habit of omitting a great deal of the information. It is suggested, therefore, that the parts list as such should call for no more information than that shown in Figure 2, but it should be used by other sections, such as production and material control, as a basis from which to prepare their own schedules in the form in which they require them.

Part Numbers

Every part shown on any parts list must have a part number and precautions to guard against duplication of part numbers are necessary, as in the case of drawing numbers. It is sometimes suggested that the use of part numbers which bear no relationship to other particulars, such as the relevant drawing, the corresponding pattern, or the jig used for producing the part, is undesirable and unsystematic, but this contention is probably quite unjustified. At first sight it might appear very sensible to use—

Part No. P.1234
Drawing No. A.1234
Pattern No. PT.1234
Jig or Tool No. T.1234/1, etc.,

but further consideration reveals weaknesses in this. For instance, there are many parts for which no drawing is required, such as nuts and bolts of standard sizes, and the practice of making drawings for such items simply to avoid gaps is rather ridiculous. Then, many items will not be made from castings and will therefore have no corresponding pattern number, while others will be produced without any sort of jig or tool. Consequently, if such a system is employed, only the parts list index will be complete and all the others will present gaps. This represents the loss of a useful safeguard. It is also suggested that in the above scheme the part number should indicate in some way the product in which the part is used. The shaft for a particular compressor might be covered by the following—

Part No. C.D.4.S.
Drawing No. A.C.D.4.S.
Pattern No. None
Tool or Jig No. T.C.D.4.S/1 and 2.

"C.D." indicates type of compressor; "4" the size of the compressor; "S" indicates shaft; "A" is the drawing size, and "T" indicates tool or jig. But what if the part in question is a bolt which is used on several different compressors, to say nothing of totally different products? This would mean that, on the material list for a totally different product, a symbol originally issued for a part used on a compressor would appear; or else two different symbols would have to be given to the same part. Then again, it is much easier for storekeepers, chasers, etc., to memorize simple numbers than complicated arrangements of symbols.

It is recommended, therefore, that there should be no attempt to establish a connexion between the numbers for the four items Part, Drawing, Pattern, and Tool or Jig. This permits simplification in directions which cause no complications. The section issuing internal orders for the manufacture of tools can earmark blocks of order numbers for tools and the tools made can bear the same number as the corresponding order. This helps in keeping a check on expenditure and on the existence of tools, independent of whether they are required for use at any particular time.

Item Numbers

The part numbers appearing on the parts list will, therefore, generally be incapable of arrangement in any sort of arithmetical order. They should be arranged in groups, each group forming a sub-assembly. Each part on the parts list should then be given an

item number starting from 1 on each parts list. The item numbers are useful in various ways, but it must be understood that a part is not generally referred to by its item number because it might appear on another parts list against a different item number, although in each case it would bear the same part number. Each sub-assembly should be given an item number and it may in some cases be useful to give a sub-assembly a part number. Thus, against, say, item 20 might appear "Comprising items 21 to 39 inclusive." Then, if a drawing is made for the sub-assembly, the drawing number may be put against the item number. This arrangement is useful to several departments, such as the buying and the estimating departments. The latter would show on their records (which, as before suggested, use the parts list as a starting point) against each of the items 21 to 39 the cost of their production, and against item 20 the cost of assembling together items 21 to 39 to form item 20.

At the end of the parts list may appear item numbers covering consumable materials, first to ensure that everyone realizes they will be required, and second to put on record that such items are defined as consumable. Where an item which is usually regarded as consumable becomes of abnormal importance, it is better to regard it as production material. An example of this is where welding rods are usually regarded as consumable material, but a contract is obtained in which there is a great deal of welding and, therefore, an abnormal consumption of welding rods. In such a case it would be better to put the welding rods on the parts list as productive material, otherwise it might well be found out too late that what has hitherto been regarded as a safe minimum stock of this item, is hopelessly inadequate. Also, even if overhead charges are departmentalized, the treatment of the welding rods as consumable material will not yield a true cost record. A further point is that the parts list would indicate the sizes and number of rods required per article.

A practice which is useful in some ways is to prefix the part numbers by a symbol indicating the class of material or the finish. Thus, B.1234 is a part made from brass stock, C.4567 is made from cast iron, while 4321 is a screw, and N.4321 is the same screw nickel-plated.

Material Description

Against each item on the parts list are given particulars of the raw material required for the part. The dimensions stated must allow for normal and unavoidable scrap, so that only material used in excess of this is recorded as genuine wastage. It is the

business of the drawing office to ensure that scrap allowances are adequate but no more, although other people concerned should be encouraged to put forward suggestions to help in this direction. Thus, where circular blanks are to be cut, the D.O. will first decide, in consultation with the planning department (if it is separate from the D.O.), whether the blanks are to be cut from strips only a fraction wider than the diameter of the blank, or whether they can be staggered on a sheet. This will depend on the tooling. Ultimately the D.O. will show on the parts list a note such as "20 cut from sheet 72″ × 12″," or whatever it may be, and they might also issue a separate drawing showing exactly how the blanks are to be cut from the sheet to avoid waste.

Similarly, a shaft might be cut from bar stock, in which case the dimensions of the stock required per shaft, allowing for parting off, would be given or the shaft might be made from a forging, in which case a separate drawing would be made showing it as a forging.

To a large extent, therefore, the estimator will get direct from the parts list the dimensions he requires to establish the cost of material in each item. Where this is impossible, the required information must appear on the drawing. The drawing for a casting would show "Estimated weight *x* lb." In due course an actual casting would be weighed and the true weight entered on the drawing when the word "estimated" would be removed. If there is much difference between the original estimate and the actual weight, an investigation is called for, because, since foundries sell castings by weight, this quite often happens. The goods inwards inspection department would check this point where castings are being bought out and the foundry inspection department when the factory has its own foundry. As an additional safeguard, the drawing office would query the matter with the inspection department, before entering the final weight on the drawing.

Part Drawings

It has now become a fairly universal practice to show only one part on a working drawing. The old idea, where an assembly or a sub-assembly was shown surrounded by all the various parts composing it, is going out of use. Assembly and sub-assembly drawings are still required, but these show only the assemblies and are drawn simply to show how the parts go together and to show operations to be performed after assembly. An assembly drawing should not show any dimensions or information which can be put on the

corresponding part drawings so that the total amount of information given on the assembly drawing can be kept down to a minimum.

Arrangement of Drawings

It goes without saying that the arrangement of drawings should be standardized. Information common to all drawings should always appear in the same place on the drawing—this point is taken care of if printed sheets are used. English projection is preferable, but clearly it is fatal to have no ruling on this point. The choice of scale depends mainly on the number of dimensions and the amount of other information to be shown. The part must be drawn large enough to enable all the various dimensions to be shown clearly. Then there should be a standard practice in regard to the method of showing drawing dimensions. That recommended by B.S.S. 308 might well be followed.

Units and Limits

Several vexed questions are raised by the English system of measurement. Some companies endeavour to work in millimetres, but they are forced to use inch dimensions for holes and diameters generally and for such items as nuts, bolts, screws, etc., and therefore both metric and English dimensions appear on the same drawing. If the English system is adhered to it is usual to work in inches except in very large work, but further complications are introduced by the fact that it is necessary to use fractions of inches and not tenths. It is quite common to express fractions in decimals, and, if this is done, good use can be made of the distinction between a fraction and a decimal by using fractions where a general tolerance is applicable and decimals where there is to be a specific tolerance. Unfortunately, inch fractions result in lengthy decimal expressions. For instance, the diameter of $1\frac{1}{32}''$ is 1·03125. Since 0·00025″ is a very small amount, it might be considered sensible to write this dimension 1·031, but it may well be that a tolerance of ± 0·0002 is put on to such a dimension. In such a case a gauge made to $1\frac{1}{32}''$ ± 0·0002 will not pass a part machined to 1·031 ± 0·0002.

It may be taken that, under present-day conditions, it is essential to use limits or tolerances. Various systems have been worked out and a great deal of trouble is saved by a decision to work to one of them—for instance, the Newall system. Details can be found in any good engineering handbook.

A most important point in this connexion is that when a draughtsman has put tolerance on all the various parts going to make an

assembly, he must then set down in two columns the minimum dimensions and the maximum dimensions of each part to see what limits apply to the final result. For example, a screw might pass through four thicknesses of metal and three thicknesses of insulation. If the metal is in each case $\frac{1}{16}'' \pm 0{\cdot}005$ and the insulation $\frac{1}{16}'' \pm 0{\cdot}010$, the total thickness may be anything between 0·4875 and 0·3875, a difference of a tenth of an inch. This tenth of an inch must be allowed for in establishing the length of the screw and must also be considered to see whether the end of the screw is likely to foul or come too near some other part of the machine.

At this point a word might be said in regard to selective assembly. In mass production it may be found that to achieve a required result it is necessary to work to very small limits and the cost of producing parts to such limits may be excessive. Provided the quantities are large enough, it is possible to use a limit, say three times as large as that which is necessary, and then to select the parts in three batches—high, medium and low—the limits of the parts corresponding in each batch.

Standardization

In a very large factory there should be a department dealing with the standardization of materials, components, small tools, etc., to ensure a minimum of variety. In a smaller factory this job should be covered by the D.O. First, rules are required regarding sizes of screws, bolts, etc., and varieties of threads to keep these down to a minimum. The same thing applies to rivets and all similar parts. Then it should be laid down that diameters should not be called for to less than $\frac{1}{32}''$ or, if possible, $\frac{1}{16}''$, in order to avoid working to very small fractions of an inch. Other rules are required, such as working to gauge sizes in steel sheets, using B.A. dimensions instead of inch fractions for small diameters. All such rules, together with instructions regarding other standard practices in the D.O., can conveniently be incorporated in "Standard D.O. Instructions" bound together in a book or index so that any new-comer can start off by studying this book, and all members of the D.O. or other interested people can refer to it as occasion arises.

In addition to the above, a standards book is required. In this book are kept particulars of what are to be regarded as standard sizes for all the various materials and components in use. These will range from obvious items, such as bolts, to less obvious items, such as sizes of steel sheets. The object should be to confine the draughtsmen, so far as possible, to the use of materials in sizes generally

recognized as standard and therefore obtainable at the lowest prices and shortest deliveries. The rule should be that no draughtsman is allowed to call for materials or components outside the sizes shown in the standards book without permission from the chief draughtsman.

The compilation of standard specifications covering the physical properties of materials should be the work of the engineering section. In this work the maximum possible use should be made of B.S.I. publications. The engineering section should then issue to the D.O. a list of material specifications for the draughtsmen to use. Thus, the properties of the various materials to be used would be defined by reference to the appropriate material specification on the parts list or drawing. This information is automatically passed on to the supplier by the buying department. When the specification in question is one drawn up by the engineering staff and is not a B.S.I. or another standard, the buying department must send a copy of the specification to the supplier with the order.

Checking

Each drawing should be checked by at least one man other than the draughtsman who made it. A fresh man often discovers a simple error which the original man will pass over time and time again. Consequently there should be no suggestion that the man checking the drawing is in any way criticizing the man who made it, so that no draughtsman need feel in the least upset if his work is checked by a junior. In a small D.O. a common arrangement is for the draughtsmen at adjacent benches to check each other's work. In addition to this the drawings should be checked by the chief draughtsman or, in a larger drawing office, by an official checker, but this is to ensure that the various rules have been adhered to and that any design points have been correctly interpreted.

The main purpose of the index of drawing numbers already referred to is to ensure that no two drawings are issued with the same number. In addition to this an index is required in which drawing numbers are recorded according to the type of product they represent. Under the letter "S" might appear a sheet or sheets giving drawing numbers of shafts arranged according to classification and sizes of machines in which they are used, and including all cases of variations from an original. In the case of variations, brief particulars should be given on the index. A common example is that of electric motor shafts, where a special extension may be called for on the order. From the index the draughtsman can find the

number of the drawing for the standard shaft and from the list of variations he can find whether this particular extension has been made before.

Serial Numbers

For various reasons it is usual to give serial numbers to articles where more than one are produced. Where true serial numbers are used, a book should be kept in the D.O., or elsewhere if preferred, in which all numbers are recorded and as they are used the corresponding order number and other brief particulars are entered. Thus, when a customer writes in for a replacement part or a complete article, if he quotes the serial number the necessary particulars to identify the job completely can be found from the serial number book. It often happens that a minor design change is introduced which does not warrant changing the type description of the article. A note can be made in the serial number book to the effect that this change was made from a certain number onwards. Alternatively, if the change was introduced when a new order was placed (as is probably usual) the order number appearing against the serial numbers will take care of this point.

Where articles are mass-produced in large quantities, it is common not to use a true serial number even though the wording "Serial No." appears on the nameplate, because the numbers would become too large, but a number is used to indicate the approximate date of manufacture. For instance, the number 342 would mean "Produced in March, 1942" and would be used for the output during that month. The next month's output would all bear the number 442 and so on. If a design change is introduced and it is necessary to make this effective at once, the number would be changed to that corresponding to the next month even though the end of the month had not been reached, so that the change of number synchronizes with the change in design.

Chapter V

PLANNING AND TOOLING

Whether the planning is done by the same team as the design and drawing or whether it is made the business of a separate department, the requirements are the same. A convenient basis is the parts list drawn up by the draughtsman. To begin with, an indication is required against each item giving the state in which it will arrive in the factory. Certain items will definitely be bought in complete; others will equally definitely be bought in as raw material and made in the factory; others may be bought in partly finished, then completed in the factory. The probability is that there will be many items regarding which some discussion will be required before a decision can be made. The planner should bear in mind that at all times the maximum possible amount of work should be done inside the factory, and at this stage should not be influenced by comparisons between the cost of making a component inside and the cost of buying it outside. All doubtful items should therefore be marked and the planner is then ready for a meeting between himself, the works, and the buying department. At this meeting some of the doubtful items can be cleared by a decision one way or the other and, in the case of the remainder, both the buying department and the planner can proceed in parallel, the former by sending out inquiries and the other by gathering information regarding the factors involved in making inside. While this is going on, the cost estimating section can be estimating the manufacturing cost so far as the information is available.

Preliminary Information Sheet

As soon as the buying department have the quotations, a further meeting is required at which more items can be settled. There will still be some cases left where the part can either be bought outside or made inside, depending on the cost. A "Preliminary Information" sheet can therefore be drawn up showing against each part the position arrived at. The final decision in regard to items still in doubt will be made by the general manager or, in a larger factory, by the commercial manager. In deciding to buy out, however, too much notice should not be taken of the cost estimate. There is no *clear* case for buying the complete component out unless the material and labour alone which would be

involved if it is made inside exceeds the outside quotation. This does not happen very often, so that generally it is a question of not being able to recover the full overhead to get a cost equal to the price quoted. Consequently, therefore, the decision is often made by studying the price in conjunction with other factors. For instance, if either part "A" or part "B" can be made inside, but not both because of machine capacity, then obviously, other things being equal, the one to be bought out is the one showing the greatest saving between the quotation received and the estimated factory cost. Again, it may be found that item "A" can be obtained in the required time and quantity, whereas all efforts have failed to get a good enough delivery promise for "B" and, in such a case, "B" would be made inside and "A" bought out.

As soon as a reasonable degree of finality is reached, a materials control schedule should be made up as a successor to the "Preliminary Information" sheet, and copies of this are held by the planning engineer, the material control section, and the production control section. It should be made the duty of the material control section to issue this schedule and keep it up to date.

The material control section then shows against each part the state in which it will arrive in the factory, the delivery dates and the rates of delivery. As further sections of the factory become involved, requests or suggestions from them may call for modification, and in order to make full use of it the schedule may have to be amended many times.

Balancing Production

From now on the planner is concerned only with those parts which are to be made inside and the other parts only in so far as they affect the final assembly. The precise form in which the information is issued by him depends on the size of the factory and on the variety of production taking place in it. In the extreme case of the single product factory, it will cover the whole manufacture down to the smallest detail. The factory layout is planned as a whole and, once started, should become automatic except for the hitches which occur due to the human element (or to mechanical break-downs), the point in this case being that planning should concentrate on organizing the factory as one machine visualizing production as a continuous process. Every effort should be made to arrange the production of each component part at the same rate as the final assembly. If the output of one part is faster than actually required, stocks representing tied up capital will accumulate, space

must be found for them, and the problem of what to do with the labour arises periodically. There must, of course, be cases where the component rate of production is far in excess of the final assembly and in these the planner should concentrate on alternating several such cases on the same machine or section. For instance, several small parts may be suitable for production on the same automatic. The planner must satisfy himself that over a period the times taken to produce the requisite number of each part, plus the setting, add up to a figure which agrees fairly closely with the time taken to produce the corresponding number of complete articles. It is when it comes to this part of his work that the planner is most likely to suggest revisions of the materials control schedule in order to put work out or buy in parts to help him to achieve a balance in smooth production.

The outstanding feature of the single-product factory is that there may be no distinct division into "shops" according to function. The machine tools will be put just where they will fit into the sequence of straight-line production and this may be done to such an extent as to result in no part of the factory being identifiable as a machine shop. The hallmark of a well-organized factory of this description is a steady output with small stocks of raw materials and components. In America there can be found many instances of single-product factories where such items as steel sheets come in one day and go out as part of the finished product two or three days later. The way in which these factories can produce a large output without requiring large areas of floor space devoted to material stocks is one of their most amazing features.

The majority of factories in this country, at any rate in the engineering industry, produce a variety of products. Where the variety is considerable, the factory is arranged in "shops" according to function. Most of the machine tools are in the machine shop, the presses in the press shop, and so on. In such a factory the planner must work in close touch with the production control section. He will start by allocating the component parts to the various shops and will only plan the final assembly in the true sense of the word. His work in connexion with component parts will be to co-ordinate the tooling and machine setting in order to make sure that his plans will not be spoilt by a subsequent discovery of inadequate capacity in one particular direction.

The planner should be closely concerned with, if not actually responsible for, the design of whatever special equipment is required. That is to say, such things as assembly conveyors, special purpose

machines, and automatic welding fixtures. Tools, jigs, and fixtures, however, required for the various components are preferably handled by a different section.

Tool Design

It is not generally an efficient arrangement even in a small factory to have toolmakers design the tool which they make, working only from the drawing of the part for which the tool or jig is required. A little and relatively cheap work with a pencil will often save a large and correspondingly expensive amount of work in steel. In the small factory, however, it is useful if the foreman toolmaker can be relied on to design the tools, although a draughtsman should be made available to work with him. Such time as he has to spare would be better spent in actual tool-making than in preparing drawings. For this arrangement to work successfully, however, the draughtsman must realize that he is working *for* the foreman toolmaker and not designing the tools himself.

Any attempt to deal with tool design would be out of place here, except perhaps in regard to one or two fundamental points. First of all there is no remedy for the complaint that tools are always too good, which comes from the man who is really manufacturing in too small quantities. It is not generally possible to make a tool to do a certain quantity before it becomes worn out or unserviceable. There is, so to speak, a basic quality in toolmaking which will give a certain quantity before the tool requires renewing, at least in part, and nothing much can be done to cheapen the tool by specifying that it is only required for a small quantity, although something may be done by spending more to strengthen up the parts at which it will wear first in order to get a larger output from it before it requires attention.

The majority of tools are required for use in conjunction with a machine of some sort and therefore the tool designer must know which machine is to be used before he starts and he must have a thorough knowledge of that machine. At this point the link with the planning engineer becomes important. For example, a part may contain three sets of holes which have to be drilled. Before the tool designer can start work he will want to know whether one jig for all the holes or one jig for each set of holes is required. In the first case the piece has only to be put into the jig once, but the jig and all the drill spindles involved are tied up until the part is finished. The rate of production is therefore the time taken to drill all the holes plus the time taken to mount the part in the jig once.

In the second case three operators and three sets of spindles can work simultaneously but the part has to be put into a jig three times. Unless, as is very unlikely, the time taken to put the part in the jig is considerable or unless, due to extreme requirements in regard to accuracy, a single jig is desirable, the second arrangement will generally be found to be preferable. Of course, the total quantity to be made must be taken into consideration since, if small, the cost of three separate jigs may not be justified.

A simple mistake which is often made is to assume that a jig made for a certain part and for a certain machine can be used for the same part on another machine. A simple rule to bear in mind is that, in the case of jigs and fixtures for drilling machines or other machines in which the work is held stationary, the tools are often suitable for use on another machine, but in the case of machines where the work revolves, it may be taken as a general rule that a tool or fixture can probably only be used on the particular machine for which it was designed.

Toolroom Programme

The toolroom programme is of considerable importance on any job. Some tools will take much longer to make than others and they should obviously be put in hand first. Allowance has also to be made for urgent tool repairs and for cases where tool design is found to be inadequate so that re-making to some extent is required. In a large factory the toolroom can be organized so that it almost becomes a separate works within the main works. It would then have its own materials control section and production control section as well as its own design and drawing office and stores, etc. In a smaller factory the same thing could be done in effect by combining several duties in one person.

The foreman toolmaker may, as suggested, act as the designer and thus control the tool drawing office. The tool drawing office can deal with materials and production control and, therefore, with the tool programme. A separate stores for the toolmakers' raw materials may be established, but, if so, care is necessary to ensure that the issue of materials from it is controlled as rigidly as from the main stores or it will be impossible to arrive at an accurate figure for the cost of making any particular tool. For this reason it is probably better in a small factory to keep the toolroom materials in the main stores. Similarly, a system must be introduced to account for labour expenditure so that this can be allocated correctly.

Tool Stores

At least one stores is required for finished tools. If this is controlled by the toolroom foreman, it will be easier to establish systematic tool maintenance, but friction may arise between the toolroom foreman and the foremen of the departments using the tools. If each department has its own tool stores to which tools are delivered as completed and in which they are kept under the supervision of the foreman of the department, greater care is required to guard against the danger of repairs to tools being neglected until they are actually required and, therefore, more difficulty is experienced in adjusting the toolroom programme. In order to provide a reserve of labour for rush jobs, a steady repair load should be included in the toolroom programme so that, as the occasion arises, a man can be made available by dropping a repair job which is not urgent.

At times when tool requirements exceed the capacity of the toolroom, the planning department in consultation with the person responsible for the toolroom programme will decide which of the tools should be bought out, but, thereafter, it is better if the toolroom have no more to do with them. The tools should be designed by the outside toolmaker in collaboration with the planner and the departments who are to use them and, on delivery, should be inspected by the factory inspection organization and not by the toolroom. In a large factory a separate inspection department for sub-contract material is justified and, if such a department exists, it can deal with the examination of tools bought outside.

The reason why this procedure is suggested is because it is rarely found that one foreman toolmaker (or ordinary toolmaker, for that matter) will approve the work of another, mainly because there are usually so many ways of dealing with a job. If the factory toolroom is called upon to inspect a tool made outside and considers it unsatisfactory, then either there will be a probably unnecessary argument with the supplier or the inside people will carry out an alteration which may quite possibly result in a failure for which neither will accept the responsibility.

Chapter VI

CONTROL OF MATERIALS AND PRODUCTION

The control of materials in order to ensure that they will be available as and when required so that production hold-ups are avoided, while at the same time the amount of capital sunk in stocks is kept as low as possible, together with avoidance of waste, is probably the most important consideration in any factory. To begin with, materials generally represent the largest single item of cost and therefore the largest opportunity to save money. Frequently a 1 per cent reduction in material consumption is worth 2 per cent or 3 per cent reduction in labour cost in terms of actual money.

Material control depends on two main factors: first, the issue of adequate and accurate parts lists and, second, efficient storekeeping. Unless the drawing office or other department responsible provides at the outset of each job a parts list showing all items of material required and their respective amounts, nothing but complete chaos will ensue. From the parts list, multiplied by the quantity on the order and the stores records of what is available, the material control clerk can draw up a series of requisitions to the buying department which form the buyer's instructions to purchase.

Classification of Materials

Materials may be divided roughly into three classes. First, those materials required only for a specific job which should therefore be purchased only against that job and in the bare quantity required plus a reasonable scrap allowance. Second, materials which are common to several different jobs and which are likely to remain in regular demand for some time. These materials should be stocked on a maximum/minimum basis. In dealing with this class, the material control clerk sets his requirements against the stock and orders as soon as the specified minimum is touched. When dealing with an extended programme his duty is to arrange the inward flow of material so that it causes the stock to float between the maximum and minimum figures. The difference between the maximum and minimum is usually the quantity which it is convenient and economic to buy at one time. Orders actually placed may be considerably in excess of this figure, but only provided delivery is specified over a period at a rate as near as possible equal

to absorption in production. The maximum quantity should also be regarded as the amount which should be available before production commences on a new line, but, in any case, it should be realized that unless the minimum figure is available it is dangerous to start production.

The system in the material control section should be such that unless a mistake is made, material is always requisitioned in good time, but as a safeguard an automatic system should be arranged in the stores whereby the storekeeper notifies the production control clerk immediately a minimum is reached. The storekeeper should always do this, leaving it to the production control section to assume the responsibility for not ordering if changed conditions have made this desirable. The storekeeper should never be allowed to fail to notify the materials control section because "he knew no more were wanted."

The third class of materials is that which may be described as "consumable material." Proper attention to this item is important because it is a charge against overhead expenses and is not an item of material consumption. Consumable materials are such things as lubricating oil, cleaning materials, and all items which cannot be specifically taken into account by the cost estimator. Ideas in regard to what should be described as consumable material may vary but the important consideration is that everything which the cost estimator cannot write down as a specific item in his cost should be included in the list of consumable materials. This again goes back to the parts list issued by the drawing office. The parts list either specifies the items of material exactly or states that they are "consumable" and these lists should always be checked by the material control clerk, before they go further, to ensure that the drawing office have not invented some new items of consumable materials.

Small tools such as files, drills, etc., may be treated in the same way, although it is desirable that a separate account is kept so that they can be transferred separately to the overheads as consumable tools and not mixed up with consumable materials.

Requisitions

The fundamental requirement in regard to all materials is that they should pass into the stores and only be removed against a piece of paper which will ensure that the cost of what is removed will be included in the appropriate cost make-up. Of course, such requisitions also serve to control waste but it is important that the people

in the factory should understand *why* they cannot get material from the stores unless they have a requisition. They should not be allowed to think that it is because nobody trusts them, otherwise an idea is created that the power to requisition materials from the stores is a privilege associated with a position of authority. On the contrary it should be stressed that it is simply because the cost clerk must be able to tell how much material has been used on any particular job.

It is recommended that the material control section make out the requisitions for all productive materials to be drawn from the stores. In any case this power should be strictly confined to one particular section. Records can only be kept straight with extreme difficulty if requisitions on the stores are issued by all sorts of people. In the case of consumable materials, power to requisition should be vested in certain responsible people in the factory, but their number should be kept down to a minimum. In a small factory it should be the works manager only, in a larger factory his assistants. All such people issued with requisition pads must be made clearly to understand that they have serious responsibilities. They must never use the pad to requisition anything which is not officially classified as consumable material and all requisitions must be issued with due regard to economy.

Apart from materials used for actual production, whether they are classified as productive or as consumable, there are various sorts of material required for such things as factory maintenance and repairs, equipment, etc. Requisitions for such materials should also be issued by the material control section against internal orders issued to cover the cost of the work involved. The only difference is that the request for the issue of the requisitions and the specification which is required to enable it to be done would not necessarily come from the drawing office.

Excess Material

There remains the item of "excess material." The requisitions issued by the material control section should always specify the exact quantity of material required for the order or batch in question. Inevitably some scrap is involved and this will call for the issue of excess material to make up the full quantity. Provision has already been made for this by the buyer in adding a wastage allowance when placing his order, but this does not mean to say that the shops would automatically be allowed to draw this excess from the stores. Some form of reject tag is required which the inspection department attach to all rejects. This tag should ultimately be marked by a

suitable and duly appointed member of the staff to indicate whether the part can be rectified or, if not, to authorize the scrapping of it. If it is scrapped, the tag should then go to the material control section and it will thus become their authority to issue a corresponding excess material requisition. Of course, to save paper, tags can be accumulated over a period and a single requisition issued to cover several. Here, however, a close connexion between the material control section and the production control section is necessary to ensure that the issue of excess material is not left too late so that it causes hold-up in production. In the case of odd items such as screws, etc., the foreman might be allowed to issue requests to the material control section for the necessary excess material requisition, but in such cases a tendency to be sticky on the part of the material control section is all to the good. The scrap tag must be cleared monthly to the cost office to enable the cost clerk to do his work as described later.

Chasing Suppliers

This covers briefly the duties of the material control section in regard to the issue of requisitions, but this section also has another extremely important duty in the chasing of suppliers. As soon as the buyer has placed an order, a copy of it should go to the material control section who will then create a follow-up card or the equivalent. On this card is given particulars in regard to the delivery promise and the rate of delivery. In all cases where the delivery will not commence under, say, three weeks, the material control section should enter on the card a date which is from 50 per cent to 75 per cent towards the delivery date, depending on the nature of the material and on past experience. The cards are then filed in order of this date. Each day the cards in the front of the file, i.e. those having that date on them, are taken out and the supplier is contacted by telephone or postcard to ask whether the material is going according to programme and the delivery date can therefore be kept. If a 'phone call is made, the information received can be entered on the card and it is then returned to the file, but this time under a new date as a result of the 'phone call. Where a postcard is sent, the new date entered should be a few days ahead in order to allow time for a reply. If the information received is satisfactory, the card should be filed under the date corresponding to the delivery originally specified. If the supplier states that delivery cannot be made, the buyer should be drawn in to see whether he can exert some additional pressure, but if this fails

a new promise must be obtained and the card filed under that date, but before this is done the production control section must be notified so that all other matters affected can be attended to and brought into line.

As the due date arrives, the card is removed and inquiries are made to see whether the material has been invoiced. If it has, the card is placed in a separate file indicating that the material is thereafter to be looked for in the goods inwards department or in the stores. If it has not, the supplier is contacted. When the material is received, the card is finished with if it is a single consignment, but if continuous deliveries are expected, the card is placed back in the file under the date corresponding to the delivery promise for the next batch.

Production Control

The planning department is responsible, as it were, for getting jobs started, but a production control section is required to keep them going. In a single-product factory this production control section is of less importance than in a multiple-product factory because, to a large extent, efficient planning and works management, combined with good material control, will do nearly all that is necessary and, conversely, the greater the variety in production the more important is the production control section.

The starting point for this section is the order. In factories where a large variety of work is handled it is usually convenient to have more than one type of order. If it has been possible to arrange that the factory is a purely manufacturing concern and there is a separate sales organization which accepts the responsibility for stocks of finished goods, then most if not all orders will be stock orders for quantities to cover requirements over a period. The longer this period can be the better. If possible, twelve months' requirements should be ordered at one time, but anything less than six months makes smooth production difficult. In addition to these stock orders, there may be other orders for relatively small quantities for certain customers and it is useful if these have a distinct series of order numbers or if the numbers have a distinguishing prefix. Then there should be an order series to cover internal work—all the odd jobs which have to be done, from installing new machines to extending the stores. The important thing is that it must be absolutely impossible for anything to be done in the factory without an order, so that all expenditure can be accounted for and analysed.

Bulk orders issued to correspond to orders for stock placed by

the sales organization might have the prefix "S." Orders placed to cover odd items to be manufactured for specific customers might be distinguished by the letter "A," and large contracts for particular customers by "C," and so on. A convenient symbol to cover work not chargeable to any customer but which is ultimately debited against overheads or capital expenditure is the letter "J." Where orders are issued monthly to cover such items as general factory maintenance, or general rectification, they should be closed at the end of each month and a new order issued. Such orders might be given the symbols "JM" to distinguish them from "J" orders issued to cover specific items such as the installation of a machine tool, or the rectification of a batch of defective components delivered by a sub-contractor since, although the expenditure against such orders is recorded at the end of each month and included in the appropriate transfer, the order is not closed until the job is completed.

Internal Orders

When the customer's order is received, the corresponding internal order is issued. In a small factory this can be done either as suggested by the general manager's personal assistant or by the cost office. In a large factory a separate order department is required. The internal order must specify the customer's requirements, translated into terms which everyone concerned inside the factory can understand. A copy goes to the drawing office via the design office, if necessary, so that all technical information required will be issued together with parts lists, etc. Another copy goes to, or is kept by, the cost office so that, in due course, they can record on it the cost and show a profit or loss on the job. Another copy should go to the works manager and another to the production control department. If this department comes under the works manager, two copies may not be necessary, since the works manager can note the order so that he knows what he has before him, and then pass his copy on to the production control section. On receipt of the order, the production control section must decide, in collaboration with the planning department and the various foremen, etc., whether the quantity is to be handled in one lot or, if not, a suitable size for the batches, and then issue production cards. Various systems are in force, but the fundamental requirements are that the production control section issues working instructions to each department concerned in such a way as to ensure that each will do its part at the required rate to fit in with the others. The produc-

tion cards must also take care of information in regard to rejects, so that ultimately the figures on it will provide the cost department with the information it requires to record the money which has been spent on the job, and the amount of useful work done for that money. In the case of a stock order extending over a long period, production cards should be issued to cover batches, each representing, say, a week's work, so that too much material is not floating about at any one time. A copy of the card or another piece of paper conveying the requisite information should go to the material control section to form the request to issue requisitions to the stores for the necessary materials.

Since the basis of a batch is a week's work, the numbers specified on cards for different components will not be equal. The production control department must, therefore, keep schedules or charts showing what they have issued, how it is progressing, and what they must issue to preserve a balance. This section must always be able to say at any time exactly how any job is going, to what extent the factory is loaded, and therefore what else can be undertaken and how it can be fitted in.

Machine Loading Chart

One example of their work is the machine loading chart. For each machine tool or group of similar machine tools they must have a card which first contains the basic information in regard to what the machine can do. On the card is entered what the machine is doing in terms of hours loading. As each job arrives it is tacked on to the existing load by being entered on the card corresponding to the suitable machine which will be soonest available. From this it is possible for the production control section to keep the machine shop foreman notified well in advance of what is coming to him, so that he can always make preliminary arrangements in order to shorten the time required to set a machine up for another job. Obviously a good knowledge of machine tool capabilities and a close contact with the machine shop foreman are essential. The information which the production control section requires in regard to the time which it will take to do any given quantity of work can be obtained from the estimating department. It is clear that the latter must have set down a figure for the time which each operation will take to enable themselves to arrive at the estimate for the job before it was quoted.

In shops where the pace is set by the worker instead of by the machine, loading charts or cards can be kept on a basis of

man-hours available for the various classes of work, and these would show the extent to which the man-hours available are booked ahead.

Chasing

The production chaser is the man who ought not to be required if the system is good and everybody else does his job properly, but in actual fact he is indispensable. The chasers may belong to the production control section or, if this section does not come under him, they may be under the works manager. Another arrangement which has much to commend it is where each foreman has a chaser as a sort of adjutant. The best arrangement depends on many factors, the principal one being perhaps the chasing method. For instance, in one method a chaser is responsible for a certain job or jobs, and follows them through no matter what part of the factory is concerned. In another method the chaser is responsible for everything made in a particular shop or department, no matter where it goes afterwards or what job it is for. In the first case it is probably better for the chaser to be responsible to the works manager and, in the other, to the production control section or to the foreman of his department. In large factories both methods may exist side by side.

The fact which really makes the existence of chasers necessary is that, except perhaps in single-product factories, the time taken to do a job is occupied more in moving the parts from one operation to another than by the actual operations themselves. As each operator does his part of the job or as each foreman sees that his department has done its part, there is a natural tendency for them to drop it and forget all about it. The man who has finished takes the view that it is not his job to hand it over to the next man, while the next man is always reluctant to go and fetch it. No amount of laying down the law about this sort of thing is half as effective as a good chaser.

Chasing Schedule

Chasers as a class are very prone to be unsystematic. They usually have very good memories and tend to rely on them rather than to put things down on paper. This is undesirable from many points of view, and it is therefore recommended that they should be obliged to keep proper chasing schedules going. In the case of a chaser occupied exclusively on one particular job, a chasing schedule should be made up which can conveniently be prepared by dividing a sheet of ruled foolscap into rectangles by drawing

vertical lines one inch apart. Down the left-hand column is written the dates for (say) a month. Along the top is put at the head of each column the various processes or departments through which the article must pass, spreading or condensing the titles so that one vertical column represents one day. Thus, if two separate operations can be done quite conveniently in one day, they appear together at the top of a column. If the next operation requires forty-eight hours, that title is spread over two columns.

Each morning the chaser goes right through the factory, and at each section or process marks the quantity finished and passed. Thus, except for rejects, each set of figures should move one column to the right each day. The rest of the day he spends in chasing after things which have spoilt, or look like spoiling, this regular move. Periodically he must see that the necessary steps are taken to bring through a batch to compensate for rejects, and that those which can be rectified are rectified and brought into the schedule again. A chaser dealing with a department instead of a certain product can use a similar series of schedules except that they would apply each to a batch of material instead of to a complete article.

Chapter VII

CONTROL OF OUTPUT

To serve the dual purpose of regulating the manufacture of the various component parts and their assembly in such a way as to achieve smooth production and to provide the information from which the cost office determines the cost of production, it is necessary to have a system whereby all operators' times are booked against appropriate orders. This system must be comprehensive, so that no operator can be paid for time which has not been booked against an order, either productive or non-productive. To check this, the total arrived at by the cost office in compiling the weekly wage analysis sheet should be compared with the amount arrived at by the cashier and entered in the wages book to provide the total for the wages cheque. The two should agree within a few pounds.

Various systems are in use, most of which have probably been arrived at by a process of addition and modification over a period of years. This is certainly an instance where there is no "right" way to do the job. Provided the system gives the required information accurately and with a minimum of cost, the details of it do not matter. However, a system will be described not because it is put forward as a model, but simply to illustrate the points which have to be taken care of.

Production Card System

Three cards are required which, for the sake of simplicity, will be referred to as the A, B, and C cards. These are as follows—

A. The Production Order.
B. The Instruction Card.
C. The Production Clock Card.

The A card is issued by the production control section. As before stated, a large order or running contract may be dealt with in batches, and therefore A cards will be issued for each batch. Where the whole order is dealt with in one batch, only one set of A cards will be issued. A separate A card is issued to each section of the factory concerned, and the cards thus issued bear a number or symbol indicating the department, so that there is no risk of two similar cards going to the same department, in which case

PD 2 DEP'T_____

PRODUCTION ORDER

ORDER No.	
DRAWING No.	
TYPE	
PART NAME	
QUANTITY ORDERED	DATE ISSUED
QUANTITY COMPLETED	CHECKED BY
QUANTITY SCRAP	DATE COMPLETED
STORES RECORD	PROD'N RECORD
NOTES	

THIS ORDER MUST BE FINISHED BY

"A" CARD

PRODUCTION
JOB CLOCK CARD

WEEK ENDING.....

NAME..... No.....

ORDER No. .....

PART..... TYPE.....

OP. No. ..... OPERATION.....

.....

TIME PER PIECE ..... PREP. TIME .....

QUANTITY ON ORDER..... QUANTITY COMPLETE.....

TOTAL TIME ALLOWED.....

MINS. B/FORWARD .....

MINS. CURRENT .....

MINS. CARRY FWD. / FINISHED .....

TIME TAKEN		HOURLY RATE			
TIME GAINED		BONUS RATE			
TIME LOST					

NET COST.....

"C" CARD

PD 8

NAME ..... No. .....

JOB No. .....

QUANTITY COMPLETED .....

SIGNED .....

"B" CARD

FIG. 3

twice the required quantity might be made. An additional safeguard against this contingency lies in the fact that the material control section would issue a requisition to cover only one quantity of materials. However, to make even more certain, cards of different colours may be used for different sections of the factory.

Where a "J" Order is issued to cover the making of something definite, such as a tool or piece of equipment, as distinct from the issue of a "J" Order for the purpose of recording labour against an overhead item, such as maintenance, an A card should also be used, but in this case the A cards should be distinct from cards issued to cover actual production either by a distinctive colour or by cutting off one corner so that they are easily sorted out.

The A cards are issued to the foreman of the departments concerned and remain in the foreman's office until the job or batch is complete. They are then returned to the production control section, so that the information which has been entered on them can be transferred to their records. As the foreman picks up each job he fills up a B card for the operator, who takes it to the time record office. The operator hands the B card in to the time clerk who then stamps the time on a C card and enters on it the job number, the operator's name, and his clock number. She then returns the B card to the operator, who goes back to his bench or machine and starts on the job. As soon as the operator has finished the batch or, in any event, at the end of the working week, he gets his output checked by the floor checker or, if it has been delivered to the inspection section, by the inspector, and the quantity completed is entered on his B card. He then takes the B card back to the time office to book off the job. The clerk stamps the time on the C card and enters the required information regarding quantity completed and passed, etc. At the same time the operator probably passes in a B card for the next job, so that the process commences again.

The C cards which are used for operators booking on items included under the heading "Lost Time" should be a very distinctive colour, say bright red, so that any member of the management passing through the time office can see at a glance the proportion of operators booked on lost time. The foreman delivers the batch, together with the A card, to the inspection section, who inspect the batch and complete the necessary information on the A card. The inspector issues reject tags to cover rejected parts, sends the O.K. parts forward to the next section, and sends the parts to be rectified to the reject disposal section. He then sends the A card forward to the time-booking office.

Reject Tags

The production control section must follow up the job to see that the parts sent to the reject disposal section are promptly inspected by the man who has authority to say definitely whether they are to be rectified, or subjected to some separate processes to salvage them, or scrapped. Where parts are to be salvaged by some process other than the simple return to the operator who originally made them, a "J" Order must be issued to cover the work, and this must be dealt with like any other order. Where the part is to be rectified by a repetition of some or all of the operations through which it has just passed, the foreman must see that the operator responsible rectifies the defective parts sent back, if possible, in his own time, i.e. they must be counted as part of the batch he is handling when his bonus earning is calculated; or if it is too late to do this and he has gone on to another job, on straight time work which must be booked against the "J" Order covering rectification. Finally, the A card is passed to the time record office so that it can be attached to the corresponding C card and the O.K. quantity checked on the C card. Otherwise the operator may be paid bonus for parts which have been rejected.

In this way the extra labour cost involved consequent upon errors in workmanship is accounted for because the amounts booked either against the general rectification order or against individual rectification orders are brought into the wages analysis sheet.

There remains, however, the value of the labour expended on parts which are afterwards scrapped. When the reject tag has been signed by the authorized person to indicate that the part is definitely to be scrapped, the part goes forward to the scrap bins and is dumped in the appropriate bin, depending on the material from which it is made. The tag is then sent to the production control section, so that a corresponding new part can be brought into existence, and from there to the cost office. The cost clerk can tell from the information on the tag the stage which the part had reached when it was rejected and scrapped, and he can therefore set down the labour cost up to that stage and record it as "Labour in Scrap." The total amount booked each month provides a figure from which is established the item "Labour in Scrap" in the direct labour oncost percentage.

Since the "Labour in Scrap" has already been booked against the job before the item was classed as scrap, it follows that the labour is automatically returned to the cost office as part of the direct labour cost of producing the batch. The production cards

show the total labour and the total number of O.K. parts, and it would, therefore, be possible to establish the "Labour in Scrap" figure from them, but this is probably more tedious than using the scrap tags.

Scrap Disposal

It must be admitted that there is a weakness in most factories in dealing with scrap and rectification. There is a natural tendency for the operator to get rid of the whole batch if he can, and a reluctance to deal with parts to be rectified in place of work on a new job or batch on bonus. Then, all concerned will probably show a marked lack of interest in parts designated "scrap." For this reason the management must insist that all reject parts are delivered to the recognized reject disposal section or sections, and must consistently discourage any attempts to park such awkward mementoes in odd corners.

A member of the staff having the requisite technical and practical knowledge, and a position which makes him immune from any influence which may be exerted by the foreman or operators concerned, must be given the job of examining everything in the reject disposal section at regular intervals and seeing that it is cleared out one way or another. In a large factory it is possible to have a staff permanently on this job, and in such a case these people might well be made responsible for seeing that the material is put through the various salvage processes, and that it is ultimately brought back into production wherever possible. In a smaller factory the responsibility for this work may be given to the production control section.

Defective Supplies

One important point in this connexion is that which arises when a defect in material becomes apparent only after some work has been done on it. It may be that a quantity of material has been passed through by the goods inwards inspection and issued by the stores for production, but when attempts are made to use it, it is found to be defective. In such a case the man responsible for reject disposal should immediately be drawn in. This man must contact the supplier through the buying department and take whatever steps may be required to prove the defect to the supplier. He must then see that the material is returned to the supplier, and must notify the accountant in writing so that a debit note is issued accordingly. The A card in respect of this consignment is returned

to the production control section indicating total scrap, so that their records can be put right. The material control section must then be notified by the production control section so that the former can see that any similar material which may still be in the stores is returned to the supplier, and that a replacement supply is urged forward. When the reject disposal man contacts the supplier, he may, in some instances, arrange that the defect is to be put right in the factory (at the supplier's expense) in order to avoid the delay which would result from sending it back. In such cases the procedure already outlined should be followed.

Inspection

The guiding principle in any inspection system should be that the number of rejections at the final inspection or test should be negligible. The department which keeps the records in regard to the final output, i.e. the order department in a large factory or the personal assistant to the general manager in a small factory, should always insist on getting the figure for rejections on final test or inspection as well as the number passed. As soon as an instance is noticed where the number of rejects is appreciable, an investigation should be made, and whatever steps are required taken to ensure that the section which has gone wrong is notified. Under no circumstances should the factory be allowed to develop the habit of putting articles up to the final inspection, like so many skittles to be knocked down. Unless the final rejects can be maintained at a negligible figure, the whole inspection system is largely a waste of money.

To achieve this object, it is necessary to have an inspection point at each stage in manufacture. Here the general rule should be to find faults at a stage where rectification is possible and cheapest, and to avoid work being done on a part which is already defective. The total number of testers and inspectors required will depend on the ingenuity with which the inspection points are thought out and grouped. In this the technical staff as well as the planning staff should be consulted.

Floor Inspectors

In addition to inspection stations "floor inspectors" will be required in certain departments. For instance, floor inspectors are very necessary in a machine shop. The main occupation of these inspectors is to examine the first few items which the operator turns out in any batch. As soon as a machine has been set up, the floor

inspector is brought along to examine the first few parts produced by the operator, so that he does not proceed with a quantity until it is clearly established that the setting of the machine is correct, and that the operator fully understands the sequence of operations which he has to perform. At frequent intervals during the period while the batch is being produced, the inspector picks up parts as they come off the machine, and checks them to ensure that the setting of the machine has not altered and that the operator has not developed a fault in technique. A floor inspector must be trained to do his work systematically, so that there are no instances where he neglects this periodic check. It must be realized that, in spite of the fact that it will really be to their benefit, operators show a reluctance to call on the floor inspector if, for some reason, he has failed to inspect their work for an unusually long period.

All inspectors, testers, and checkers should be made responsible to a chief inspector so that they are independent of the various foremen in whose departments they work. Whether the chief inspector is responsible to the works manager or to the general manager will depend on the calibre of the works manager. If he is little more than a head foreman, then the chief inspector should be on the same level, and therefore responsible to the general manager. If, however, as would be the case in any but a very small factory, the works manager is a man of sufficient character to hold a balance between quality and quantity, the chief inspector should be responsible to him.

Inspection Standards

Inspection standards should be clearly laid down at the commencement of a job, and a limit system must be used by the drawing office so that all dimensions shown on drawings are subject to appropriate limits. Questions of quality in regard to finishes, etc., can be laid down by means of approved samples kept in a suitable place for reference. Neither the chief inspector nor any of his men should be given any authority to depart from the standards laid down. They should, however, be encouraged to use their discretion and refer to the works manager or the general manager when they find a case where, although not complying strictly with the standard laid down, the article is, so far as they can see, satisfactory. In such circumstances they may be given a concession to pass the particular article or batch in question. In all such cases the chief inspector should obtain the required permission, and this should be covered by the issue of a "concession" or "technical instruction" by the

drawing office putting in writing the precise variation agreed, and the exact part or number of parts to which it applies so that it is not taken as a precedent. All managers must be most careful not to allow themselves to give verbal permission to pass out material which is not quite to standard because, if this is done, it will afterwards be found that the permission has been taken as a precedent, and that the standard has thereafter permanently been lowered. It will probably be said that this process holds things up and stops production, but there is no reason why it should. If such cases are found, the cure lies, as in many other cases, not in allowing the process to be short-circuited, but in taking steps to see that it is followed through expeditiously.

Where, as a result of experience, a permanent alteration in an inspection standard is decided on, the drawings or other manufacturing information in question must be modified, so that this alteration is clearly distinguished from a temporary concession applying only to a particular part or batch of parts.

Chapter VIII

BUYING

It is a curious fact that the best-hated man in a factory is often the buyer. The explanation seems to be that whenever there is a serious hold-up in production it is nearly always due to trouble with material supplies. The material may not be available when required, or it may not come in fast enough to keep production going, or it may be rejected as unsuitable. All these troubles are automatically and instantaneously thrown back at the buyer, whereas in all probability he is not to blame.

Generally speaking, it is probably better that the buyer should confine his attentions to buying only and, except in a very small factory, he will find this a full-time job without taking on anything else. There are, however, several other functions which have to be fulfilled to enable the buyer to do his job and, although they will now be discussed as if they are done each by a different person, as before stated, the combination of these jobs by giving more than one to any individual, including the buyer, must depend not only on the amount of work to be handled, but, what is more important, on the characteristics and capabilities of the staff available.

To deal, however, with buying itself, it may be stated that here this function is defined as the business of finding a suitable supplier for anything and everything which the factory requires and issuing orders accordingly. The means whereby the buyer is told what is wanted and the contact which must be established with the supplier after he has the order, are the business of the material control section.

Index of Suppliers

Assuming that the buyer has before him a list of materials required, giving all relevant particulars, he would first consult his index which has been built up over a period of years. This index contains a card for every item previously bought, giving the name of the supplier. Of course, there are obviously cases where one card may be used for more than one item. From the cards for similar or related materials the buyer will obtain the names of people who can probably supply the item in question, and with whom he has previously had dealings. Incidentally, the card should show some reference to the supplier's reliability in regard to delivery promises and standard of workmanship.

There is no need to keep a second index showing the names of several possible suppliers against each item of material because, having already got the name of one probable supplier, the buyer will either call to mind others, or can get them from a trade directory by consulting the pages in which appears the name of the one he already has. It goes without saying that inquiries should be sent to more than one supplier. At the same time the practice of sending out dozens of inquiries is wasteful and unfair to the suppliers, and eventually reacts by causing many of them not to treat the inquiries seriously. It is, therefore, preferable that not more than three inquiries should be sent out at first and others afterwards if any one of these three is negative or very much different from the other two. Also to ensure serious attention each inquiry should be an "original."

Suppliers' Representatives

Having received quotations, the buyer will probably find suppliers' representatives will follow them up by calling without being asked. It is important that such representatives should receive proper treatment. If the representative is calling to see the buyer of his own accord, he should not be kept waiting around for hours not knowing how he stands. If the representative is asked to call, then time and date should be specified, and the buyer must see to it that he keeps the appointment.

In order to deal with casual callers as well as to cope with his other work, it is best for the buyer to fix certain days, or certain hours, when he can be seen. A notice regarding this should be posted in the waiting room and the same information printed on the inquiry forms. In this way the suppliers' representatives will soon get to know the arrangements and will conform to them. As each representative arrives his name and business should be entered on a slip, and the slip passed into the buyer at once. After one glance the buyer can say whether there is any point in seeing the man or not, and here it must be stressed that fairness is called for even under trying circumstances. If the reply is in the negative, the representative can be told and he can then go away without further waste of time. If in the affirmative, he can be given a time when the buyer will probably be free to see him, and he can then please himself whether he waits or calls back. If he is not back when his time comes, the next man available gets the turn. The time arranged is entered on the slip and passed again to the buyer who keeps it before him. The times on these slips tell him when to terminate each interview.

Technical Representatives

There is another type of representative who must be treated rather differently. This is the man who is calling, probably by request, to discuss technical matters. In such a case the buyer's duty is to make the appointment on behalf of the technical man who wants to see him and to pass the representative over when he arrives. On their part, however, the technical staff must understand very clearly that they are not allowed to give any promises in regard to orders, although they may discuss prices if necessary. Also the technical man must afterwards advise the buyer, preferably in writing, of what took place at the interview.

It really must be remembered that representatives not only deserve decent treatment, but if they receive it they can become a real help to a buyer instead of a nuisance. Once a buyer can establish a reputation for being fair and reasonable, he will earn the respect and friendship of his suppliers and their representatives, and this will stand him in good stead in difficult times. The job is to guard against any sort of favouritism which, once embarked on, is likely to create awkward situations.

Classification of Purchases

The buyer's instructions regarding what he is to buy come from the material control section who issue to him "purchase requisitions." These requisitions fall into the following categories—

1. Items required in relatively small quantities for specific jobs.
2. Items required for specific jobs but where production will extend over a long period.
3. Items required to maintain stocks kept on a maximum/minimum basis.
4. Consumable materials and consumable tools.
5. Stationery, publicity, drawing office materials, etc.
6. Materials required for internal work such as maintenance and repairs and toolmaking.
7. Items of capital expenditure.

Materials for Specific Jobs

1. In order to avoid wastage or the accumulation of redundant stocks, it is important that the buyer should not order for a specific job more than the exact quantity required plus a scrap allowance. He should, therefore, issue orders corresponding strictly to the purchase requisitions. Scrap allowances for various classes of

materials should be standardized as a result of experience, and a table given to the buyer for his guidance.

Materials for Long-term Production

2. Where the order or contract placed on the factory covers production over a lengthy period, the purchase of materials calls for rather different treatment. Early notification to the buyer to give him the maximum possible time is of great importance. Then, in order to get the lowest prices, the buyer will want to place orders for the total requirements, but, to avoid excessive financial outlay, he must arrange for suppliers to deliver at as near as possible the same rate as the rate of production on the finished article in the factory. He should bear in mind that the factory will take some time to build up to full production and, therefore, while early deliveries are important to enable them to start, excessive initial deliveries of certain items may become embarrassing.

The material control section and the buyer must keep in touch with the planning department while the job is being launched so that they do everything possible to get the various materials into the factory in the required sequence. This means that they must plan the buying in line with the production plan. The extent to which they concentrate on certain materials before others would depend not only on what the factory requires first, but also on which materials they know from experience will probably take longest to obtain.

Standard scrap allowances should not be used in this case. Provided the point is raised at the outset, and provided they are given ample notice, suppliers will probably agree that the actual quantity to be supplied need not be stipulated exactly at the outset. The buyer should, therefore, place his contracts for the quantities equal to the number of articles to be produced on the contract, adding a scrap allowance only where it is clearly necessary and, even then, working to a minimum figure. As soon as the end of the contract is in sight, the factory must take a physical stock of all materials on the job, and from this figures can be obtained from which the buyer can finalize deliveries from the various suppliers. This suggestion calls for considerable work on the part of the individuals concerned, but the savings which result from it make this work very well worth while.

Max./Min. Stock Items

3. Many of the materials stocked on a maximum/minimum basis will be items standard to the suppliers, such as screws, nuts,

bolts, etc. There is no reason, therefore, why these should not be ordered in accordance with the material control section requisitions. Where this is not so, it will be necessary for the buyer to place an order covering several months' requirements and to specify a rate of delivery based on past experience. The material control section will then accelerate or endeavour to reduce this as may be necessary by direct contact with the supplier. The original purchase requisition will, therefore, cover considerably more than the difference between the maximum and minimum figures and, until this is nearly exhausted, the material control section will, instead of issuing a purchase requisition when the stores stock touches the minimum figure, contact the supplier to urge the next delivery. The supplier will be requested at the outset to deliver in batches equal to the difference between the maximum and minimum figures.

Consumable Items

4. Consumable materials and consumable tools in regular demand can be treated in the same way as productive material kept on a maximum/minimum basis. This, however, must not be done where a quantity of consumable materials is required only for a particular contract and will probably not, therefore, be required when the contract is finished. If the drawing office should specify an unusual item of consumable material on a small order, the material control section should insist that this be treated as direct material. For instance, if paint is usually regarded as consumable material, but on a particular order for a relatively small quantity a brand or colour not hitherto stocked is called for, this should be treated as direct material.

5. Requirements in regard to stationery, drawing office material, etc., need not be handled by the material control section. The accountant, the chief draughtsman, or other departmental manager concerned can place requisitions direct on the buying department.

6. Materials required for internal work should be requisitioned by the material control section in the same way as productive materials. As far as possible they should be stocked on a maximum/minimum basis, in which case the procedure already outlined will apply. There will, however, be items such as spare parts for machine tools where nothing may be held in stock, and usually this class of material is required in a great hurry. The maintenance engineer or other person interested should not be allowed to requisition the buyer direct because of the danger of duplication, but a strict rule

must be laid down that such requisitions are to be given priority by the material control section and dealt with immediately.

Capital Expenditure

7. Items of capital expenditure should be dealt with direct between the general manager and the buyer. Of course, the original request will probably come from the works manager or other departmental head, but this must be made to the general manager so that if he approves he can ask the board for the necessary sanction. A record of all sanctions for capital expenditure should be kept in the general manager's office and against each, in due course, the money actually expended should be entered, including the cost of installation. It must be realized by all concerned that expenditure on the capital account must be strictly controlled within the figures sanctioned by the board.

It will be seen later that, to provide the necessary figures for budgetary control, it is necessary that expenditure on non-productive materials should be analysed monthly. This is done by arranging transfers from the purchase journal to the appropriate accounts of expenditure on all items other than productive material. To facilitate this work the buyer should segregate the orders at the outset according to the necessary number of classifications. This may be done by the use of a prefix or suffix to the order number. For example, Order No. 12345/10 may cover the purchase of a portable electric drill, the suffix /10 indicating that it is to be debited to the account "Consumable Tools."

Analysis of Purchases

As each invoice is received by the invoice clerk it is stamped (Fig. 4) and the clerk enters against the word "analysis" the account to which the invoice is to be debited. This he can tell at a glance, if the supplier has repeated the order number in full, but if, as sometimes is the case, the supplier omits the suffix, it is the clerk's business to find out the correct classification and enter it accordingly.

If required, productive material may be split also. It may be that there are one or two very large and important contracts on which it would be useful to note exactly what material is being purchased month by month and, in such cases, the above procedure can be adopted.

As the invoices are entered in the purchase journal, the amounts can be entered into separate columns according to the classification.

At the end of each month then, the accountant can arrive very quickly at the various sums to be transferred to the different accounts.

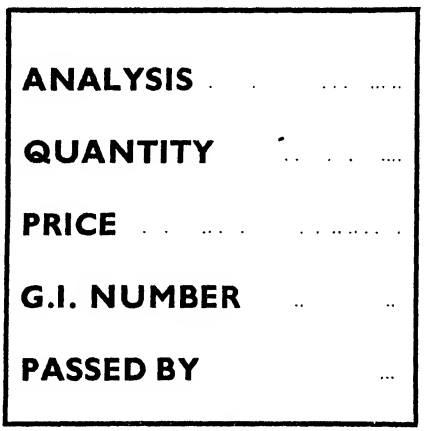


FIG. 4

Subcontracting

As a result of deliberate policy or arising out of a change in circumstances, the factory may purchase a considerable amount of machined parts as distinct from raw materials. Where parts are quite finished and are bought out because they require specialized plant and experience, such as die castings or synthetic resin mouldings, the matter can be handled quite satisfactorily by the buyer. But, in the case of parts to be machined, such as castings or shafts, especially if only part of the machining is to be done, the buyer may not have sufficient practical experience or technical knowledge to ensure that he places the orders with thoroughly reliable subcontractors.

Generally speaking, a subcontractor who is looking for work is liable to be optimistic in regard to his performance. Should, however, it be found at a later date that lack of deliveries from a subcontractor holds up production in the factory, it is a poor consolation to be able to blame the subcontractor for optimism. It is therefore important that someone from the factory, having the required knowledge and experience, should visit the subcontractor at the outset and satisfy himself that the plant and workers available are really suitable for and capable of doing the job. In a large factory a subcontracts department is justified. In a smaller one

this preliminary inspection of a subcontractor's plant may be done by the works manager or, in the less important cases, by one of his assistants or foremen. The buyer's job would then be to find subcontractors who consider themselves suitable and to arrange for the works manager's inspection. As soon as the works manager has expressed his satisfaction with one of them, the buyer would place the order. Thereafter the material control section would chase the material in the ordinary way, but should they find any difficulties arise, they would contact the works manager for help.

CHAPTER IX

GOODS INWARDS

THE control of materials coming into the factory and their storage until required is of importance in two distinct ways: first, as already indicated, to ensure that the materials, correct in variety, amount, and quality, are always available when required for production—this is the business of the material control section—and, second, to take care that the large sums of money involved are correctly accounted for and kept down to a minimum. Again, it must be repeated that in most factories expenditure on account of materials is higher than on labour—probably at least double—and therefore attention to waste of all kinds is correspondingly important.

To some extent the steps taken to achieve one end also help to achieve the other, but it is important to watch carefully that the system worked to is not laid down and regulated, on the one hand, by a production engineer seeing the problems involved only from his angle nor, on the other, by an accountant who thinks only in terms of the money involved and has no regard for the effect on production.

The Payment Aspect

To deal now with the problem more from the accountant's angle, it is necessary to discuss the information which must appear on the order to assist, in due course, the handling of the material and the payment for it when it arrives at the factory. For the sake of simplicity, the case of a multiple-product factory will be dealt with, but the same procedure is largely applicable to a single-product factory.

All orders placed by the buying department must be covered by the issue to the supplier of an official order on the company's official order form. Any orders which may be placed under exceptional circumstances by telephone or word of mouth must be confirmed by the issue of an official order and, in such cases, the order must bear the wording "confirmation of telephone order" or whatever may be required to ensure that the supplier does not deliver a double quantity.

Where several classes of work are being handled, a separate order series or distinguishing suffix to the order number series should be used for each class, and the file copies of the orders put

together in their different classifications. This enables separate figures for material purchases to be easily arrived at for each class of work. Similarly, orders for factory maintenance, consumable materials, consumable tools, etc., must also be segregated under their respective suffixes so that expenditure on these accounts can be arrived at with the least trouble.

Where the material is required for a particular order, either for a customer or for some internal work, the factory order number must also appear on the purchase order so that there will be no confusion later in making sure that the material goes to the people who require it, and in making sure that it will be charged to the correct cost account.

Distribution

In the case of consumable materials and other items where the instructions to the buying department to place an order do not come from the material control section, the purchase requisition, although signed only by the person allowed that responsibility, should also be initialed by the particular person originating the request. These initials should then appear on the purchase order so that when the goods arrive at the factory the goods inwards department will know the individual who is waiting for them. For instance, if a foreman whose initials are "H.J." wants a particular sort of portable electric drill he will take the matter up with the works manager and, if the latter agrees, will write out a purchase requisition for the works manager to sign, initial it himself, and pass it over to the buying department. The order to the supplier will therefore carry the following information to ensure that it is charged to the right account, and reaches this particular foreman as soon as possible after delivery—

Order No. 12345/10—(/10 meaning that the material is to be debited to "Consumable Tools").

Requisition No. 6789/H.J.—(from which the goods inwards department can trace the requisition if a check is necessary and from which they know the name of the particular man who is waiting for the article in question).

In such cases the goods would be delivered direct to the man who initialed the requisition, and he would sign for them on the goods inwards note in place of the storekeeper who signs for all goods going into the stores. Clearly, no goods must be passed direct without going through the stores, except where such initials appear on the requisition and on the order, and only provided the person whose initials they are signs the goods inwards note. Also the works

manager will not sign the purchase requisition or, if he does, the buyer will not accept it unless both are satisfied that the material in question does come into one of the categories where this procedure is allowed, and that the individual whose initials appear on the requisition is a person specifically allowed to use this privilege. The number of people thus privileged should be kept down to a minimum.

Where the material comprises finished components having part numbers, the appropriate part numbers must be entered on the purchase requisition by the material control section, and also on the purchase order issued by the buyer.

Pricing of Orders

All orders must be priced and the delivery date stated. That is to say, the price quoted by the supplier, together with the delivery date he has promised, must appear on the official order, and only under most exceptional circumstances should "open" orders be passed; when this happens, confirmation of the price must be obtained as soon as possible and then entered on the file copy of the order, together with an adequate reference to the way in which the price was confirmed. Naturally, confirmation in writing must be made so that if the price should be given over the telephone by the supplier, a letter should immediately be written to him confirming this telephone conversation, and the reference to this letter is the one to be entered on the copy of the order with the price.

Goods Inwards Notes

When goods arrive at the factory, they will be normally preceded or accompanied by an advice or delivery note. The goods inwards department should, in respect of each consignment of goods delivered, make out a goods inwards note. This G.I. note will have a number of duplicates, depending on the number of departments to be notified separately regarding the arrival of the goods, but the number of copies should be kept down to a minimum and the last copy should be left permanently in the book. The sets of G.I. notes should be numbered in series, and preferably the copies should be of different colours. The top copy of the G.I. note goes to the material control section to enable them to transfer the information to their materials chasing file and other records. This copy should then be filed in the material control section. The second copy goes to the buying department to check the particulars and price against the order, and to record the deliveries on the back

of the file copy of the order as a check on the materials control section records. This copy, initialed by the buyer to confirm that the particulars are correct, then goes to the accounts section. When the total deliveries entered on the copy of the order equals the total originally specified, the order is "closed" to prevent the acceptance of excess deliveries.

A separate series of G.I. notes, preferably of different colours, should be used to cover materials returned from customers, such as packing cases, rejects, repossessions of materials sold on hire purchase, etc. In this case the top copy can be endorsed "Return Note." This copy goes to the accounts department, who satisfy themselves that the customer who returns the goods is entitled to a credit and then pass a credit note. The copy of the credit note, together with the G.I. note, is filed together in the central file.

If the company is operating more than one factory or branch works, it is probably advisable also to have a third series of G.I. notes to cover material passing between establishments. Such notes would not apply to materials coming back from a separate sales organization since they would, so far as this is concerned, be treated as a customer.

Contact with Material Control Section

Whichever category the G.I. note falls into, it must not be simply a copy of the information entered on the supplier's delivery note. The G.I. note must show the quantity stated on the supplier's delivery note, the quantity found to be correct after checking at the factory, and the number passed by the goods inwards inspection as being O.K. and passed into the stores. If the G.I. checker is not specifically obliged to enter the number on the supplier's delivery note as well as the number actually counted, he will skip the counting and copy the figure off the delivery note. All copies should be kept together until the goods have reached the stores, so that the storekeeper can sign for the quantity finally received by him. When the copies pass on, therefore, the material control section note as having been received only the quantity passed into the stores, while the accounts section issue a debit note against the supplier covering the rejects and pass the account for payment only in respect of the quantity passed into the stores.

This procedure inevitably means some delay in getting G.I. notes to other departments. It is, therefore, recommended that a separate scheme be applied which will have the effect of letting the material control section know when material urgently required

has arrived. For instance, the material control section can give the G.I. daily a note of such material which can be posted up in a permanent position. As soon as any item on the list arrives, a mark can be made against it and the material control section notified or, if a representative of that section visits the G.I. periodically, he can obtain the information in that way.

Debit Notes

To ensure that only material accepted into the stores is paid for, the accounts department must issue debit notes to account for the difference, if any, between that accepted and that invoiced by the supplier. The debit note should always be made out by the accounts department. To begin with, all copies should be sent to the G.I. inspection department, so that that department can send them, with the defective goods, to the dispatch department. The dispatch department will dispatch the goods, enclosing the third copy as a dispatch note; the top two copies will then be sent to the buying department, so that they can be priced from the order and then passed on to the accounts department. The accountant will post the top copy to the supplier to whom the goods have been returned, and will retain the second copy for accounts purposes. As soon as the necessary book entries have been made, this copy is filed in the central file in numerical order, so that all debit notes issued can be accounted for. The fourth copy is retained in the dispatch department.

The accounts department must assume the responsibility for chasing up the G.I. inspection and the dispatch departments to ensure that this procedure is promptly followed out. Unless the accountant does this the goods will lie about for weeks and ultimately, because of this delay, the supplier may refuse to accept them back.

Price Checking

All incoming invoices must pass through the buying department so that the price can be checked. The accounts department then check against the appro ate G.I. notes and, where there is any discrepancy either in price or in quantity, issue the required debit note. Where a consignment of material or component parts urgently required for production is rejected by the goods inwards inspection, it may be considered advisable, where possible, to rectify the goods in the factory rather than return them to the supplier. Where such a course is adopted it is the duty of the buyer to get the supplier's

agreement. An internal order is then issued to cover the work, the defective goods are passed into the stores in the usual way, and requisitioned out by the material control section against the internal order on which the rectification work is to be done. The G.I. note would then bear the wording "To be rectified on J.1234." When rectification is complete the material is returned to the stores, the order is closed, and the cost office notify the accounts department the amount involved, so that the G.I. note which has been held in suspense can be cleared by the issue of a debit note to the supplier for this amount.

A procedure is also required to deal with materials sent out of the factory temporarily. For instance, component parts may be sent back to the original supplier for repair, or material or partly finished component parts may be sent out for work to be done on them by a subcontractor. In such cases the original of the repair order or subcontract order issued by the buying department should be sent to the accounts department instead of direct to the supplier. The accountant will then make out debit notes, all copies being marked "Open Entry" where no price has been agreed, but, of course, as far as possible a price should be agreed in advance and the accountant should always demand an explanation from the buyer before agreeing to an O.E. order.

The top copy of the debit note should be attached to the order and the two sent to the supplier or subcontractor. It is advisable to have a standard notice fixed to the order stating that credit for the material will be issued when it is returned to the factory. The second copy is sent to the purchase department to be filed with the copy of the purchase order, the third and fourth copies to the dispatch department so that one can go with the goods, and the other be retained in that department. On receipt of the invoice from the supplier, the accounts department will check against the goods inwards note that the amount passed into the stores is correct and is, in fact, the actual material in question, and will then clear the debit note in the books.

Chapter X

HANDLING THE FINISHED ARTICLE

Before dealing with the disposal of the final product, it is convenient to consider those items which are finished in themselves, although not to be dispatched as such to a customer, that is to say, finished components which are ultimately incorporated in a final product.

As far as possible, the rate of production of components should be regulated to conform to the rate of production of the final article. In pure mass production this object is achieved to a surprisingly large degree, but where real mass production is impossible, this objective should still be borne in mind and every effort made to achieve it.

If a component part is produced at a much greater rate than is required by the rate of the final assembly, it is clear that there will be an accumulation of such parts. If the quantity allowed to accumulate becomes large, then, for many reasons, it cannot be left lying on the floor of the shop, but must be put into the stores and treated from then on in the same way as a consignment of material which has been purchased from a supplier.

The sort of thing which happens in relatively small scale production is that a single machine which is set up to produce a certain part will produce that part at, say, three times the rate at which the final article is being assembled. The person responsible for machine shop activities is tempted to run the machine for a considerable period, and to produce several weeks' requirements at one run. This saves "setting up" time on the machine, but it involves extra cost in storage space, transportation of parts in and out of stores, and money tied up in stocks. If, in any factory, a few specimen cases are fully investigated, taking all factors into consideration, it would probably be found that it would be better to impose a restriction on lengthy runs and endeavour to arrange that the accumulation of components does not exceed what can be safely kept on the floor of the shop.

Size of Batch

Cases where the rate of production of a component is of the order of two to five times that of the final article are probably more difficult to decide than cases where the component is produced at a much greater rate. Where the production of large batches of a

component is unavoidable, they must be delivered to the stores for safe custody and, subsequently, issued to the final assembly day by day along with other parts kept in stock, against requisitions issued by the production control section.

The decision in regard to this matter cannot be left to the foremen concerned. If it is, there will be no uniformity in procedure and a great deal of waste and trouble. The foreman of the old-fashioned type, especially if he supervises the making of the component as well as the assembly of the final article, will be most reluctant to pass the component into stores and then draw it out again. The more up-to-date man may err in the opposite direction. He may tend to give undue consideration to long runs and fill up the stores with certain components while starving the assembly of others.

If the production control section regulate the production of components by the issue of job cards or the equivalent, this section should decide on the economic batch and whether the length of time the batch will last the assembly section is such that the parts must go into stores. In such cases the job card would be endorsed with a rubber stamp, "Deliver to X Stores." It would be clearly understood that where this endorsement appears, the parts must go to the particular stores indicated, but where a card is not so endorsed the components made against it will be passed straight on to the next section.

There may be occasions when some of a batch of components are so urgently required by the assembly section that it would obviously be foolish to waste time passing them into stores and drawing them out again. In such cases the parts would actually pass direct to the assembly, but would go through the stores "on paper." By the exercise of a little common sense this is easily done, it keeps the job going and, at the same time, keeps the stores and production control records straight.

Sub-Assemblies

So far, components have been spoken of as if each were always a single piece of material produced off one machine, but a component, although a single piece of material, may be the product of several different machines, or it may be the combination of several smaller components, i.e. it may be a sub-assembly. Where it is a single piece of material but is dealt with on more than one machine, then, following the policy already recommended, every endeavour should be made to run the machines simultaneously and

at substantially the same rate of output, so that each part is passed through all processes in sequence and there is practically no accumulation between the machines. Where the rate of working of the different machines is unavoidably so different that this cannot be achieved, then parts may have to be put into stores in a partly finished condition, but this can often be avoided by regulating the size of the batch so that if, say, the first machine deals with the whole in two days, while the second machine requires four days for the same quantity, the temporary accumulation of parts on the floor between the two machines is not excessive.

It is recommended that, as far as possible, the rate of production of sub-assemblies should be arranged to be equal to the rate at which they are required by the final assembly so that they need not go into stores. In this connexion a point which often arises is that a sub-assembly as such may be comparatively delicate or easily damaged, and thus difficult to store and handle with safety. When dealing with sub-assemblies, the problem of regulating the rate of production is generally easier than when dealing with machined parts. The "setting up" involved is often negligible since, generally speaking, no machine tool is used and labour is the only factor to be considered. Trouble mainly arises where the scale of production is such that only one or two workers are involved in making a sub-assembly. For instance, if the final article is being produced at twenty per day, while a single operator can assemble a certain sub-assembly at fifteen per day, then one operator on the job is not enough, while two operators are too many. The solution is to bring several sub-assemblies into the same section so that the operators, by working for different lengths of time at different jobs, will achieve a balance over a week or a fortnight. Incidentally, such an arrangement provides an insurance against loss of output when absenteeism occurs.

Use of Parts List

One essential requirement to enable production to be regulated in this way is the use of part numbers. Not only must each finished part have a number, but so must each sub-assembly, and where a part is at all likely to be sent to stores in an unfinished state, then a separate number again is required to distinguish that state.

Suppose a shaft starts life as a forging, is machined on a capstan, then has other parts assembled on it, and is finally ground on the journals, it is safe to say that there should be four different part numbers to distinguish these four stages. If only one part number

Issue No.	1					Generator	Part List No.: 1234	Sheet No.: 2 Of. 5
Date								

Item No.	Part No.	Drwg. No.	Description	No. Off	Size	Material	Remarks
16	S4976	S7149/B	Commutator Assembly comprising items 17–22 inclusive	1			
17	C4953	XS7098	Commutator Bar	45	1″ long section to Dwg.	H.D. Copper	
18	H4937	XS7016/C	Insulating Segment	45	$1\frac{1}{16}$″ × $\frac{13}{16}$″ × 0·030″	C.A. Mica	
19	H4977	XS7159	Insulating V Ring	2	$1\frac{15}{32}$″ dia. × $\frac{31}{32}$″	Micanite	
20	H4978	XS7173	Insulating Tube	1	$1\frac{3}{16}$″ × $\frac{15}{16}$″ × $\frac{41}{64}$″		
21	F4945	XS7084	Commutator Hub	1	$1\frac{1}{8}$″ dia. × $1\frac{3}{8}$″ long	Br. M.S.	
22	F4938	XS7068	Clamping V Ring	2	$1\frac{3}{8}$″ dia. × $\frac{15}{32}$″ long	Br. M.S.	
30	S4980	M7174/A	Armature Wound Assembly comprising items 31–49 incl.	1			
31	S4970	M7172	Armature Core Assembly (see Item 1)	1			
32	S4976	S7149	Commutator Assembly (see Item 16)	1			
33	H4982	S7157/A	Armature Insulating Disc	2	$\frac{1}{16}$″ thick	Presspahn	
34	C4983		Armature Coil	45	$1\frac{3}{8}$ lb. No. 19 s.w.g.	Fine d.c.c.	
35	H5018		,, Slot Insulation		96″ × $3\frac{1}{8}$″ × 0·012″	Emlin	
36	M5019		,, ,, ,,		84″ × $\frac{1}{2}$″ × 0·007″	Superfine C. Tape	
37	M5020		,, ,, ,,		36″ × $\frac{1}{4}$″ × 0·007″	,, ,, ,,	
38	M5022		,, Coil Sleeving (Black)		$12\frac{1}{2}$ ft.	O.O.S. Sleeving	
39	M5023		,, ,, Tape		50 ft. × $\frac{5}{8}$″ × 0·007″	Superfine C. Tape	
40	M5015	XS7164	,, Slot Wedge	23	$3\frac{1}{16}$″ lg. to Dwg.	Beech	
41	M5019		Connection tape		20 ft. × $\frac{1}{2}$″ × 0·007″	Superfine C. Tape	
42	H5025		Coil Packing N.D.E.		25″ × $\frac{3}{8}$″ × $\frac{1}{16}$″	Presspahn	
43	H5026		,, ,, D.E.		16″ × $\frac{9}{16}$″ × $\frac{1}{16}$″	,,	
44	H5027		Banding Insulation	4	6″ × 3″ × 0·010″	Elephantide	
45	F5028		,, Wire		$\frac{1}{4}$ oz. × 0·029″	Steel B. Wire Tinned	
46	F5029		,, Clips		$1\frac{1}{8}$″ × $\frac{1}{4}$″ × 38 s.w.g.	Brass Strip Annealed and Tinned	
47	M5030		String		1 yard	String to M.S. 739	
48	H5031	XS7170/A	Armature Washer	1	0·78″i.d.× $2\frac{1}{2}$″o.d.× $\frac{1}{16}$″	Presspahn	
49	H4961	S7110	Fan	1		18 s.w.g. Sh. Steel	

FIG. 5

is used, it is very easy to make a mistake and work on the assumption that a batch of these parts in the stores is finished, whereas, in fact, it is only at the second stage and such a mistake may have very serious consequences.

The drawing office should, therefore, draw up the parts list in such a way that individual parts are grouped in sub-sub-assemblies which are each given a distinguishing part number. The sub-sub-assembly part numbers are grouped again in appropriate sub-assemblies, which are, in turn, given their part numbers and so on, as illustrated by Fig. 5. The figure reproduces one page of a parts list for an electric generator. It will be seen that Item 16, Part No. S.4976, is a sub-sub-assembly (the commutator). Grouped immediately under this item are the various parts comprising it. Item 30, Part No. S.4980, is a sub-assembly (the complete armature). Items 31 and 32 are two sub-sub-assemblies which are incorporated in Item 30, being respectively the armature core ready for winding and the commutator which appears on the sheet in question as Item 16. In this way a part number may appear more than once on the parts list, but a sub-assembly or assembly, or a part at its second or subsequent distinct operation, is easily picked out because there is a blank space against it under the "Material" column, since material is specified only against the part number covering the part at its first stage in manufacture. It should be noted also how this arrangement of the parts list assists the cost clerk. Against the Part No. 4976, Item 16, he enters only the labour required to assemble the commutator. Against each subsequent part of this sub-sub-assembly (items 17 to 22 inclusive) he enters both the material cost and the labour cost of making each item.

Delivery Notes

Turning now to the final article which has passed through the various stages of production, including whatever final test and inspection are appropriate, and has arrived at the dispatch department, a system is required to cover the activities of the dispatch clerk. One suitable system is the use of a customer's dispatch note (C.D.N.). The clerk makes out the dispatch note, Fig. 6, in quintuplicate. Machines are available which facilitate this operation. The five copies are used as follows—

First Copy. Dispatched to customer by post.

Second Copy. Dispatched to customer with goods.

Third Copy. Presented by vanman to customer's representative for signature acknowledging receipt and thereafter brought back

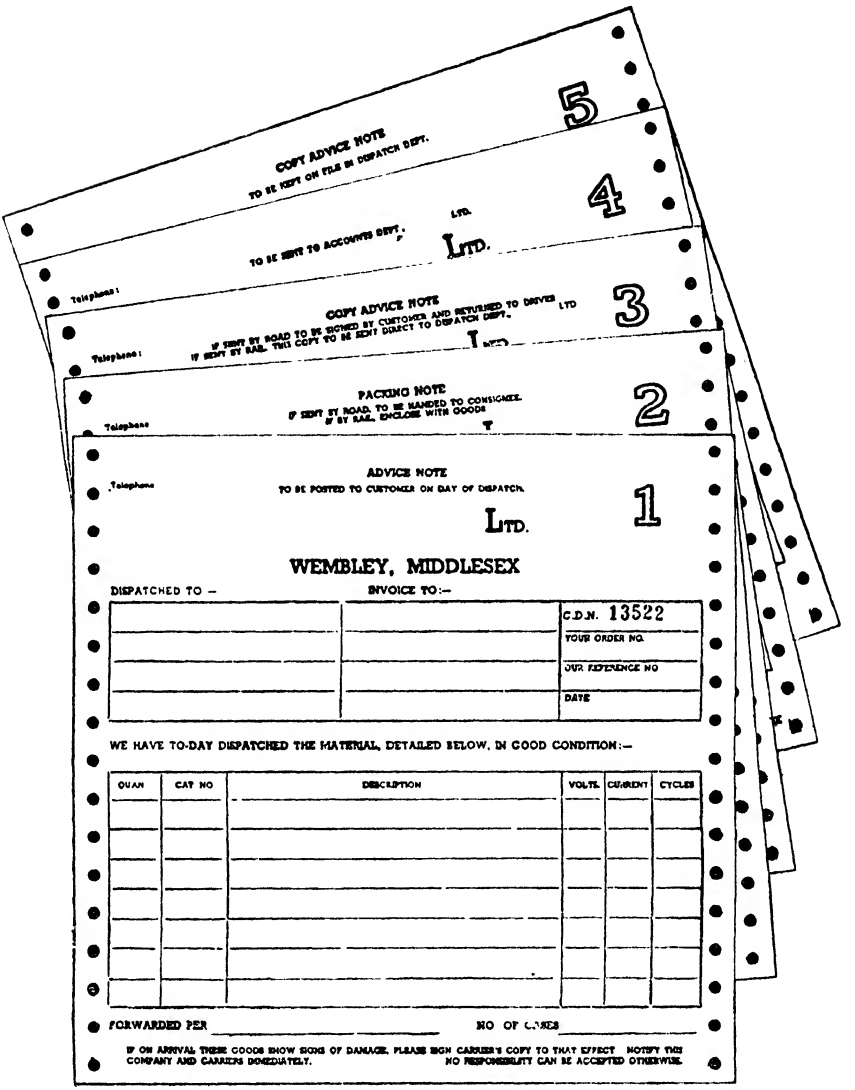

COPY ADVICE NOTE
TO BE KEPT ON FILE IN DISPATCH DEPT.
5
TO BE SENT TO ACCOUNTS DEPT.,
LTD.
4
Telephone:
COPY ADVICE NOTE
IF SENT BY ROAD TO BE SIGNED BY CUSTOMER AND RETURNED TO DRIVER
IF SENT BY RAIL, THIS COPY TO BE SENT DIRECT TO DISPATCH DEPT.
LTD
3
Telephone:
PACKING NOTE
IF SENT BY ROAD, TO BE HANDED TO CONSIGNEE.
IF BY RAIL, ENCLOSE WITH GOODS
2
Telephone
ADVICE NOTE
TO BE POSTED TO CUSTOMER ON DAY OF DISPATCH.
Telephone
LTD.
1
WEMBLEY, MIDDLESEX
DISPATCHED TO —
INVOICE TO:—
C.D.N. 13522
YOUR ORDER NO.
OUR REFERENCE NO
DATE
WE HAVE TO-DAY DISPATCHED THE MATERIAL, DETAILED BELOW, IN GOOD CONDITION:—
QUAN
CAT NO
DESCRIPTION
VOLTS
CURRENT
CYCLES
FORWARDED PER
NO OF CASES
IF ON ARRIVAL THESE GOODS SHOW SIGNS OF DAMAGE, PLEASE SIGN CARRIER'S COPY TO THAT EFFECT. NOTIFY THIS COMPANY AND CARRIERS IMMEDIATELY.
NO RESPONSIBILITY CAN BE ACCEPTED OTHERWISE.

FIG. 6

to works and handed into the accounts department. This procedure is only required where the goods are delivered by the factory's own transport, and takes the place of the document which the carrier uses to cover himself when the goods are delivered by outside transport.

FOURTH COPY. Sent to the order department for pricing in the case of an article made against a quoted figure, or to the cost office for pricing where some other arrangement in regard to price was made when the order was accepted. This copy then goes to the accounts department and there becomes a "posting medium." It is used by the accounts department to make out the invoice or to debit the customer's account.

FIFTH COPY. Depending on the nature of the product, this copy may not be required. It is sent to the service, or maintenance, department which is responsible for after-sales service to purchasers. From it the service department make out their card or other document on which they keep a record of customers who may require service or maintenance at some future date.

Delivery to Stock

The C.D.N. procedure described applies when a factory is consigning goods direct to a customer. It has already been suggested that, wherever possible, the sales department or associated selling company should place stock orders with the factory so that its deliveries against such orders would not be for consignment to a customer but for delivery to a finished material stores. As the materials are delivered into these stores they become the property of the sales department or the associated selling company. The delivery note procedure is suitable for use by the dispatch clerk operating from the finished material stores, but since he would be employed by the selling company and the documents would go to their accounts department, it would be better to use a different colour to distinguish such C.D.N.'s from those used by the factory.

In a small concern it may well be that, although goods going into the finished stores then become the property of the sales department, the stores is within or adjacent to the works and the same personnel handle goods into stores, goods to customers direct from works, and goods from stores to customers. If this is so, then one accounts department would handle all C.D.N.'s, but, clearly, the use of different colours would facilitate the work of pricing and crediting to the correct account.

Where a stock order scheme is in force, the C.D.N. form should

not be used to cover material delivered by the factory into the finished material stores. All that is required is a simple form on which the dispatch clerk enters the material put into stores, which the storekeeper signs to acknowledge receipt. This form goes to the accounts department as a posting medium. It is advisable that a representative of the sales department should check periodically the stock against the account. If it is physically possible, this should be done once a month, but where the variety and quantity is so great that this is out of the question, then the annual stock-taking must be relied on for a check. The point is that every item which goes into the finished material stores should be accounted for. The only possibility of error (and this is why the sales department must check the stock) arises either from the goods being sent out without proper authority or factory personnel persuading the storekeeper to acknowledge receipt of goods which he has not actually received. It must be remembered that if the stock order scheme is in operation, occasions may arise when, to improve the factory output figures, the factory personnel endeavour to obtain credit for articles which they have just failed to get into the stores on the last day of the month because of some hitch or other. The objection to this is not that the factory received a credit a few days before they should, but that confusion may be caused, resulting in discrepancies in stock figures which take time and trouble to clear up.

Chasing

Connected with the dispatch of goods to the customer or the consignment of components to the stores are the problems of internal chasing and external contact with the customer. A better appreciation of the importance of chasing may be created by studying it in this connexion.

The customer who has not received delivery in accordance with the promise made to him will invariably complain. The progressive customer will write before the job is due in order to find out whether the maker expects to deliver on time. Such correspondence is handled by the order department or, it is suggested, in the small company by the general manager's personal assistant. The representative of this department will soon discover whether the job has left or is on the point of leaving the factory, but if this is not so he is obliged to get some idea of when it will leave and the most likely source of this information is a chaser.

The chasers are the people who try to keep everyone to the programme which will result in delivery on time. In the case of

relatively large scale production or production spread over a long period, one of their most important tasks is to see that components are produced and passed to stores or final assembly in good time to avoid a hold-up in assembly.

In a factory where a variety of products is dealt with (and this is probably the average case) it is often found that more time is taken up between operations than in performing operations themselves. This state of affairs has one advantage—it renders a speed-up possible. As soon as the order department representative initiates a move to accelerate the production of a certain job, the chasers set about reducing the time between the various operations.

In so far as this only entails overcoming ordinary human inertia, no appeal to authority is necessary, but delay between processes is generally also partly due to programme arrangements. The extent to which delay is due to this cause is a good indication of the efficiency with which planning is carried out, although it must be borne in mind that planning may have been upset by the failure of the material control section to secure delivery.

Where, in order to speed up delivery, an alteration in programme is required, the chaser must contact the planning department. If he is allowed to persuade or instruct the foreman to put the urgent job in a machine in place of something else, a serious dislocation may occur having final consequences far more serious than the failure to deliver the job in question. It is important, therefore, to frame rules which must be followed by members of the order department in their dealings with the shops and the activities of the chasers to ensure that these considerations are taken care of. Rules which are comprehensive but simple and rigidly enforced will not only result in efficiency, but will help to preserve a good spirit among the individuals concerned which, in itself, produces better results than any amount of "efficiency."

At this point it may be useful to give some consideration to the question of transport. It is assumed that railway transport will be used whenever suitable in any case and, therefore, it is only road transport which is in question. There are three basic possibilities—

(1) The factory may own vehicles and operate them itself, but this does not exclude the possibility of using other road transport in addition as the necessity arises.

(2) The factory may rely entirely on road transport contractors or carriers.

(3) It is possible to make a contract whereby the contractor supplies vehicles as and when required. Although these vehicles are

the property of the contractor, they may be designed to suit the user and painted and marked as if they were the property of the user.

Factory-owned Vehicles

Where the factory owns the transport, it is obvious that it is possible to purchase vehicles which are either specially designed or chosen from the varieties available to suit the particular products which they will have to carry. It is often found that, by the use of special fitments, products can be carried without the necessity for elaborate packing and packing cases, and this saves a very great deal of money. Also, when the product is such that it is easily damaged in transit, the direct control makes it easier to guard against this. It must not be forgotten that the cost of repairing transport damage is often excessive in comparison with the cost of manufacturing the article in the first place and, in any case, the damages which may be collected from a carrier are really very poor compensation for the real losses involved.

The vans may be marked or painted in distinctive colours and thus act as advertisements for the owners, but in this connexion it must be borne in mind that, unless maintenance and upkeep are properly dealt with, this type of advertisement may have an effect opposite to that intended. Finally, if the factory owns its own vehicles, then it has always something available to collect materials from suppliers in an emergency. This is an asset not to be overlooked because there are many occasions on which the loss involved in a production hold-up far exceeds the expense of collecting materials from a supplier who is behind in deliveries.

There are certain disadvantages in factory-owned transport which must be taken into consideration. To begin with, the capital outlay in the purchase of the vans may be a problem. Then it must be emphasized that proper maintenance is absolutely essential. This means that either the factory must maintain a competent maintenance staff adequately supervised, which is only possible if the factory is large enough to employ a considerable number of vehicles, or a contract should be made with a garage to do this work. If the matter is left to be arranged "as and when," satisfactory maintenance will almost certainly not be forthcoming. In any event, if the scheme involves only a small number of vehicles, the necessary withdrawal of a vehicle at least twice per annum for overhaul causes a serious temporary dislocation. In considering a scheme it is better not to assume too readily that seasonal variations in trade will enable vehicles to be withdrawn for overhaul without causing difficulties.

One essential point is adequate supervision. Transport vehicles must be under the charge of a man both competent and reliable who will ensure first that the drivers behave honestly and, second, that the vehicles are properly looked after. The transport drivers of necessity spend the majority of their time away from the factory, and the indirect supervision consequent upon this is more difficult to maintain than direct supervision. Apart from legal requirements in regard to the maintenance of a log book, it is necessary from the point of view of control to ensure that drivers account for their time and mileage in a proper manner.

Where the vehicles themselves are concerned, it will often be found that drivers are extremely careless and, in fact, ignorant of the functioning of the mechanism. Only careful supervision by a competent man will guard against very rapid deterioration due to such carelessness. Even repairs consequent upon accident may cause serious difficulties. Although the cost of the repairs is borne by the insurance company, this may be negligible by comparison with the cost of alternative arrangements which have to be made while the vehicle is out of commission.

Outside Transport

There are obvious advantages in using outside transport, such as the elimination of capital expenditure, maintenance, and supervision, but certain less obvious points must not be forgotten. Where the business of the factory is such that it is the custom to sell goods at a price which excludes the cost of delivery, then outside transport should be used, otherwise the factory will find itself doing something for nothing because it will be unable to recover from the customer the cost involved in using the factory delivery vehicles. Where the factory is small so that, in any event, only one or two vehicles would be operated, it is probably better to rely on outside transport because the cost of proper supervision would almost certainly be prohibitive. The work involved in contacting carriers and transport contractors to guard against trouble and delays is the sort of work which can be dealt with by a dispatch clerk in a small factory, whereas the same man would be unlikely to have the necessary mechanical knowledge to supervise the proper care of vehicles.

On the whole, the disadvantages which arise from relying on outside transport are not so serious as is often imagined. A great deal depends on the product which is being handled. If this is robust and not easily damaged in transit, there is very little to worry about, but where the product is delicate or easily damaged in

transit, then reliance on outside transport is a serious matter. One thing which often causes damage is that carriers have their own centres at which they transfer materials from one vehicle to another.

Contract-hired Vehicles

On the face of it an investigation shows that the cost of the contract-hire scheme is greater than where vehicles are owned by the factory, but it must be remembered that, in addition to all the direct items which can be definitely evaluated, there are many contingent or indirect expenses arising from the various points discussed which do not appear where a contract-hire scheme is entered into. The hiring company maintains the vehicles in first-class order and the withdrawal of the vehicles for repair, maintenance, or overhaul is not noticed by the user. As before mentioned, the vehicles can be painted and marked as if they were owned by the factory. The whole problem of supervision is taken care of in a very efficient manner; there is no capital outlay involved and no necessity for a maintenance staff and shop and, finally, no factory space wasted in garages.

As in the case of many other factory matters, the important consideration in transport is that once a scheme is decided on it should be adhered to. It will be found that where a contract-hire scheme has been entered into, or where it has been decided to rely on outside transport, there is often a constant agitation for a small van to do the odd jobs. This must be sternly resisted. On the other hand, if the factory owns its own transport, it must be laid down that only a certain responsible official is allowed to authorize the employment of outside transport, and this same person should be the one to give the decision where it is a question of rail *versus* road. Otherwise it will be found that the factory's own vehicles are spending many hours in idleness while the goods are being handled by someone else.

CHAPTER XI

LABOUR

IT has already been said that the human factor is always much more difficult to deal with than any of the technical problems which arise in manufacture, and labour is possibly the most formidable of all. It is perhaps a pity that in writing and speaking on factory matters the usage of words is such that an atmosphere of impersonality is always created in regard to labour. The idea which is adumbrated and, in fact, which seems to exist in certain minds, is that working men or women in the main become a commodity to be bought and sold like the material on which they work. The fact that they are human beings seems to be forgotten until they do something very human which administers an awakening shock to the employer. Since, however, they are human beings it seems not only fair that they should be treated as such, but possibly more likely to yield good results.

Federations and Unions

To begin with, the company operating the factory should belong to its appropriate employers' organization. Incidentally, quite apart from labour matters, it will be found that such an organization gives a tremendous amount of valuable and up-to-date information on a wide variety of subjects connected with the industry in question. From this it follows that all conditions in regard to wage rates and other matters affecting workers, which have been agreed with the unions, will be observed.

Some employers who do not belong to their organization stand out because they have a fear of, or repugnance towards, trade unionism. Both are quite unwarranted. The worker has a perfect right to join his union if he wishes, and any attempt to persuade or coerce him not to join is not only wrong but may lead to trouble. As a matter of fact, if the employer observes all the conditions agreed between his organization and the unions, he will very likely find that large numbers of his employees do not join a union for the simple reason that they feel the union can do nothing for them, and they cannot see the point of paying a subscription for nothing. Conversely, in the factory where the employer does not observe those conditions which have been agreed by the industry, trade unionism is likely to be popular and forceful.

Works Committee

As soon as a factory becomes any size it is a help to the management if the workers are organized in some way so that their troubles and difficulties can be dealt with conveniently through representatives. The works manager should, therefore, form a works committee, the members of which are representatives from each part of the factory, plus himself and some other members of the staff representing the management. The committee should be fully representative, but the smaller it can be kept the more efficiently it will work. Those workers who belong to unions will probably elect "shop stewards," but it does not necessarily follow that these stewards will become the representatives on the works committee unless the trade unionists are in the majority. Consequently, it might be better to avoid the use of the term "shop steward" in connexion with the works committee in order to accentuate the fact that the members of it must be elected by, and therefore will represent, all the workers in their respective departments, whether unionists or otherwise.

It will be found that all major issues are automatically settled by applying the agreements made between the employers' organization and the trade unions. Should any serious matter arise in the factory, the employers' organization will supply a representative who can give valuable assistance in straightening it out. The works committee will, therefore, mainly be concerned with minor matters, some of them perhaps very trivial indeed. The works manager should be patient and sympathetic, and he will find that in time the committee will settle down and the trivial things will disappear. Once a shop representative is experienced, he will settle many matters with his mates himself and not bring them forward to the committee at all.

The rules of the committee should lay it down that any worker who has an individual complaint should raise it first with his foreman. If he is not satisfied with the answer he may then ask his representative to take the point up with the committee. It will generally be found, however, that most problems affecting only the individual will be settled by a sort of three-cornered conference between the foreman, the shop representative, and the operator concerned.

Matters affecting whole bodies of workers will generally be referred to the committee. The committee should also be closely connected with social activities, football clubs, etc. This is a great help towards creating the right spirit. The object to keep in mind

always is to destroy the idea that the workers and the executive are on opposite sides of a fence. The truth is that they are both on the same side with economic conditions on the other.

In order to comply with the law certain services, such as first-aid, must be provided. It costs very little extra, but helps a great deal if these services are combined and expanded to form a welfare department. Again, a close link between the welfare department and the shop committee is valuable, particularly where a large proportion of the workers are girls.

Wage Payment System

Whole volumes have been written on the subject of wage-payment systems, and there is possibly no more controversial subject in the industrial field. There are, by this time, few responsible people who object to the principle of payment by results, but, on the other hand, it would almost seem that the stage has been reached where some of the exponents of what might be described as the extreme systems are quite as ridiculous as the old-fashioned man who still believes in straight time payment.

There are, of course, classes of work in which any sort of payment by results is a practical impossibility, but the general principle which is accepted is that some form of incentive should be offered wherever it can be arranged. It does not follow that any particular system is the "right" one or, indeed, that any single system is applicable throughout a factory unless engaged on the manufacture of a single product. In order to simplify the control of labour costs, it is desirable that the factory should be engaged on work falling into the same category in regard to the degree of mass production involved. That is to say, it is desirable that the factory should either be working on mass production or on jobbing work or, if on some intermediate stage, various products should as far as possible be on the same level. This is probably very difficult to achieve but, nevertheless, represents a desirable aim, and if it can be achieved it will probably be found possible to apply one system of wage payment throughout the factory except for the few unavoidable instances, such as the toolroom, where there is no alternative to straight time work.

The object of a wage-payment system is twofold. First, to encourage the worker to achieve a greater output and, second, to afford some analysis of the "Lost Time" so that it may be accounted for and reduced to the lowest possible level. It must be realized that it does not necessarily follow that certain systems give both of

these requirements while others give only the first, although, in actual fact, this is sometimes found to be the case because a system has been applied to less extent than it might.

Piece-work System

A popular and simple system is that known as the piece-work system. In this the operator is given a price for a job. That is to say, he or she is told that a certain sum of money will be paid for each of a particular component made by the operator. In actual fact, however, the piece-work basis is really time. The rate fixer arrives at a time which the operator ought not to exceed in doing the job, working at a reasonable speed; he increases this time by a margin to enable the operator to earn a bonus and then translates that time into terms of money according to the operator's wage rate. The system has certain difficulties in its application, created by such things as the agreement to pay the operator not less than his basic rate so that, should he fail to do the work in the time allowed, he will, in effect, have to be paid more than the price stipulated. For example, an operator whose basic rate is 1s. per hour might be given a price of 6d., i.e. a rate of thirty minutes each for a certain operation. If he is an average worker he might do the job in twenty minutes and he will thus earn 6d. in twenty minutes, which is at the rate of 1s. 6d. per hour or time and a half. If, however, for some reason he cannot do the job in less than three-quarters of an hour, he must still be paid at the rate of 1s. per hour and, therefore, in effect he is paid 9d. each for the operation in question. In some systems he is made to "run into debt" when this happens, so that he cannot earn bonus until he has made enough pieces at less than thirty minutes each to make up for those where he took more than thirty minutes. Such systems are, however, generally very unsatisfactory. In a well-organized shop with efficient rate fixing there should be very few instances where operators cannot make bare time. It should be noted in passing that some method of recording instances where the operator fails to make time is required. Clearly, when this happens, the job costs more than the rate fixer allowed, therefore if it happens to any appreciable extent it would result in an unexpected financial loss. On the average, however, operators should earn bonus and, if they do, the effect should neutralize the effect of operators who fail to reach the rate fixed.

The piece-work price usually includes allowances for fatigue, setting up, tool sharpening, and all the other incidentals to the

actual job. The man is expected to be able to complete the operation or make the piece in the time allowed without any extra allowance for all these odd things. If, however, he is faced with a really serious hold-up, he is generally allowed to appeal to his foreman, who, if he cannot clear the hold-up, agrees that the man should book off the job. With reference to what is to follow, however, it should be noted here that there is no reason why any required causes of delay cannot be excluded from the piece-work price, and the man allowed to book on to an order covering that particular item. For instance, if desired, a rule can be made that setting-up is to be excluded from all piece-work prices, and an internal order number can be issued to cover setting-up. This would mean that when an operator was given a job to do he would book on the setting-up order until he is ready to start work, and then book on to the job itself.

Points System

The other instance of wage-payment system which will be examined may, for the sake of simplicity, be referred to as the "points system," although it must not be inferred that any system using the term "point value" is necessarily so elaborate or, indeed, is correctly described by what follows. In this system the operator is given a point value for a job. This is actually the number of minutes taken by an average operator working at a normal speed and subject to no interruptions. Such an operator is said to be working at the rate of sixty points per hour. Before proceeding, attention might be drawn to the method of arriving at "point values," because this method has excellent features and can, in fact, be applied to any other system, including the piece-work system.

The rate fixer times several operators each over several repetitions of an operation. He may, of course, subdivide what is ultimately to be regarded as the complete operation into a series of smaller operations and study them separately. This will lead him to his secondary job of suggesting alterations to methods which will reduce or eliminate some of the motions. Assuming that all this has been done, he collects the above observations, the important point being that each time he makes a study he writes down a figure to indicate how hard he considers the operator was working at the time, e.g. sixty for working at normal speed, forty for working slowly, and eighty for working quite hard. When he comes to average out the various studies he has taken, he can, by taking into

account this figure, adjust the times recorded to compensate for periods during which operators were working at different intensities. If the job warrants it, other rate fixers repeat the process and their work is averaged out also. It is clear that such an arrangement must lead to establishing very reliable rates.

Analysis of Lost Time

It was stated above that the point value is the time which the job would take, provided there are no interruptions. From this it follows that the operator must be allowed to book off the job for each and every interruption with which he is faced. Indeed, the system requires him to do this because it stresses the importance of the second object, that is the analysis of the lost time. A series of stop numbers may be drawn up covering twenty to thirty or even more items such as waiting for instructions, waiting for materials, waiting for setting or receiving instructions, setting-up, waiting inspection, etc.

In theory the operator will be quite sure to book off the job on to one of these stop numbers when the situation arises because, otherwise, his bonus earnings will be affected, and by analysing the time booked against these various numbers it can be seen what is happening to the labour which is not devoted to definite production. This is all very well *provided* so much time and money is not spent in getting the analysis that none is left to enable something to be done about it, and also provided that a corresponding amount of time and money is spent on the factors which cause losses in labour, although, strictly speaking, nothing to do with it. For instance, it is clearly not very sensible to spend large sums of money in labour analysis where the labour cost is, in any case, not more than 20 per cent of the factory cost, while paying no corresponding attention to the control of materials, which might well be 50 per cent of the factory cost, especially as, in all probability, the most serious single cause of lost time is hold-ups due to lack of materials consequent upon this inadequate attention to the handling of them.

However, the whole arrangement depends on the assumption that the booking of operators can be taken as reasonably accurate. In actual fact, however, when one considers the possible number of interruptions throughout the day, it seems likely that no reasonable degree of accuracy can be expected. If a man were to make a real attempt to book accurately, he would occupy so much time in the actual process of booking that another stop number would

have to be created to cover this. The chances are, therefore, that the man will endeavour to reduce the number of times he books off the job by taking minor interruptions in his stride, and making them up by booking extra time against the other stop numbers when he does book off the job.

Apart from the question of accuracy of booking, there are other serious objections to this system. The fact that he is supposed to book off the job as soon as he is faced with an interruption is liable to destroy the operator's initiative. It can quite easily be imagined that if a capstan operator breaks a tool during a run, his first concern would be to book off the job on to the stop number "Waiting new tool." If he feels tired he will probably do nothing until he has had a rest. If any complaint is raised he will probably say that he is waiting for the capstan setter although, in actual fact, he has not told anyone that he is waiting. It is only when the foreman notices that the man is standing idle, or the man himself becomes tired of doing nothing, that the situation is brought to light and something is done about it.

Then, again, since an attempt at really accurate booking against the appropriate stop numbers for interruptions is practically impossible, the operator takes steps which not only affect the accuracy of the records, but may ultimately become actually dishonest, so that by clever manipulation in booking he earns an inflated bonus to which he is not entitled. A man might quite easily be faced with as many as twenty interruptions in a day, and he only has to steal one minute at each end of each interruption to gain forty minutes in the day and, in effect, get forty minutes' wages for doing nothing. The cost of adequate supervision to guard against these points is formidable.

Group Bonus

In the case of mass-production jobs and, in particular, where a certain article is being produced in large quantities in a factory in which other articles are being produced in relatively small quantities, a group bonus scheme is very effective. Such a scheme can best be described by means of an example. Suppose the article is to be passed through its various processes by a total of twenty operators. Work is commenced as soon as the layout and the materials are ready, and the operators are paid their basic rate of wages with, possibly, an arbitrary bonus in order to encourage them while the whole of the operations are carefully examined by time-study engineers. When this examination has been carried out

it is possible to assess an output which this team ought to be able to achieve. A figure should then be written down for the output which the team will produce without undue effort (i.e. working at sixty performance). This enables a basic production figure to be given to the team, bonus being paid for all production in excess of this.

The team in question might comprise the following—

		Hourly Rate	*Bonus Rate per 60 Points*
4	Male operators	18 pence	12 pence
4	Youths	9 pence	6 pence
12	Female operators	13·5 pence	9 pence
20	Average rate	13·5 pence	9 pence

Assuming that the basic output at sixty performance arrived at by the time-study engineers is twenty items per hour, then if in any one week the workers average thirty per hour they score thirty bonus points per hour. If they succeed in producing forty per hour they earn sixty bonus points per hour. Each operator in the team, therefore, scores the same number of bonus points, but the various classes of workers in the team receive different rates of payment for these points.

This system has the following advantages—

(1) The maximum labour cost of the article is 13·5 pence each. As the output increases and operators earn bonus, the labour cost comes down by virtue of the fact that the bonus rate is less than the hourly rate. From the above figures it will be seen that, if the operators succeed in producing forty per hour and thus earn "double time," the labour cost per article comes down to 11·25 pence each.

(2) The cost of production is readily arrived at week by week, so that a constant check can be kept without difficulty.

(3) The operators are working on a system which they find easy to understand and which, therefore, they like.

(4) Since the bonus which any individual earns depends on the result of the work of the whole team, there is no difficulty in regard to lines of demarcation. That is, if one operator is ahead with his or her operation, there is no difficulty in getting that operator to lend a hand with a more difficult one or with some unusual problem which has arisen temporarily.

Analysis of Labour Expenditure

The criticisms of the system where wage analysis is carried to extremes should not be taken as a suggestion that no attempt should be made to analyse expenditure on wages. The contention is that, taking everything into consideration, it is probably better to compromise on a less detailed analysis.

To begin with, all piece-work rates or point values should include an allowance for minor hold-ups and for setting where the setting time is small compared with the time which will be taken for the batch. It must then be clearly understood by all that no operator will be allowed to book off the job unless faced with a chronic hold-up and, in any case, only by permission of his foreman. Thus any time occupied in attempting to clear the hold-up or in getting permission to book off the job is against the operator, so that he is automatically encouraged to use his initiative in clearing the hold-up. Also work should be promptly inspected so that rejections can be put right by the operator while the batch is still in progress. It must be realized that if an operator can, he will endeavour to finish off a batch and get on to another job before the first one is inspected. Then, if rejects are found, a separate job will have to be made of putting them right. This is not only wasteful in that it means the operator is paid more than is fairly due to him, but it involves additional setting-up, which is a serious matter, especially if done by a skilled setter and not by the operator himself.

Booking of Time

To cover the cases where an operator is allowed to book off the job, monthly "J" orders should be issued under the various headings. Against each is shown the items which, under a more elaborate system, would be separated but which are here grouped together. If it is found that any one heading becomes a large proportion of the total, it should be divided again by the issue of a larger number of monthly "J" orders so that expenditure on the heavy items can be attacked. In addition to actual production, i.e. labour done on work for which a customer will pay, and "Lost Time," being payment for time during which an operator ought to have been producing, there will be many cases where an operator is employed on work which is legitimate but, nevertheless, not productive. The first example of this is where the operator is producing something to be paid for on the capital account, such as tools or the installation of a new machine. Then there are such items as factory maintenance, plant maintenance and experimental work where the labour

involved is to be charged against overheads. In such cases there should be "J" orders issued to cover specific items and monthly "JM" orders to cover general work. Where orders are issued for specific items, however, especially in cases of experimental work, the amount spent each month should be added up irrespective of whether the job is completed or not, and the appropriate transfer made in the books. Otherwise over a period a considerable expenditure may go on undetected.

Wage Analysis Sheet

Thus, no operator can be paid for any time which is not accounted for, and the total amount spent under the various headings should add up to a sum equal to the gross wages for the week. An example of weekly wage analysis sheet is shown below.

.....**Ltd.** **Date issued**.....

WAGE ANALYSIS FOR WEEK ENDING *16th May.*

	%	£ s. d.	£ s. d.
CAPITAL EXPENDITURE			
Tools and Equipment Product A		4 7 6	
Tools and Equipment Product B		2 1 9	
Other Work		– – –	
			6 9 3
TRANSFER TO OVERHEADS			
Experimental		8 5 9	
Plant Maintenance		12 8 6	
Factory Maintenance		4 3 1	
Tool Maintenance		7 10 –	
Transport Maintenance		2 – –	
Consumable Tools		8 5 3	
General Labouring		68 3 –	
Instruction and Setting		85 1 9	
Operators Undergoing Training		17 6 3	
			213 3 7
LOST TIME			
Rectification		15 4 2	
Waiting Time		3 9 7	
Excess Labouring		5 14 –	
Excess Instruction and Setting		10 1 9	
Excess Training Operators		9 4 –	
	6·07		43 13 6
PRODUCTION			721 17 2
Total Wages Paid			£985 3 6
Overtime Increment (included)	2·3	22 13 –	
Paid Holiday Reserve (excluded)	2·67	19 5 –	
Labour in Scrap	5·2	37 10 –	
Direct Labour Oncost	16·24		

The time which operators work on the various "J" orders is recorded on the appropriate job clock card, following the same procedure as for productive work. The job clock cards go first to the wages section so that the necessary details can be entered on the operator's earnings record from which his wages packet is made up, and then to the cost office. In the cost office the operator's name, time worked, and rate can be entered on the record card corresponding to the order and against each entry the cost in money is worked out and put down. Thus, at any given time the total expenditure on an order can be arrived at, and each week the expenditure on all orders in each category can be ascertained. The total amount entered on cards belonging to the productive series becomes the total productive labour for that week, while the total entered on the various "J" order cards, gives the non-productive labour expenditure which is split as shown under the two headings, "Transferred to Overheads" and "Lost Time."

Direct and Indirect Labour

For the purpose in question, the total productive labour is not split up, but is entered on the analysis sheet as a single item. The non-productive labour is shown against the various appropriate items. The first group representing the labour to be transferred to overheads should be compared with the forecast and, provided no item is higher than the estimate, there is nothing much to be done. The total of the transfer to overhead plus the lost time should always be examined in order to detect any tendency to reduce one by transfers to the other, which can happen through incorrect booking, deliberate or otherwise. The second group represents the lost time and efforts should always be directed towards reducing this. The total for the lost time expressed as a percentage on the productive labour is one item in the direct labour oncost.

The total amount paid out in overtime increment is extracted from the operator's earning record cards. The holiday reserve made against each operator is extracted from the wages book. Both are entered on the weekly-wage analysis sheet, and the appropriate percentage figures worked out and set down. The percentage for the overtime increment is arrived at by taking the total amount of money disbursed in overtime increment divided by the total wages paid, but the holiday pay figure is arrived at by taking the ratio of the sum of money set aside to the amount paid out in *productive* wages.

Labour in Scrap

The wage analysis sheet then gives all the information required to deal with expenditure on wages, except the labour content in scrap. The information should be entered on a collective sheet so that in respect of lost time and the major items of overhead transfers, the percentage for each month can be arrived at. The percentage for the lost time can then be used by the estimating section during the following month. The figures for labour to be transferred to overhead thus arrived at are passed to the accountant, so that he can make the necessary transfer in his books, and include them in his figures which he shows on the monthly financial report.

It should, of course, be noted that the amount which the accountant shows in the monthly report against "Productive Wages" is the total of expenditure on true production plus lost time, i.e. it is all wages other than transfers to overheads or the capital account. For this reason it is probably better to keep the employer's contribution to national health insurance and unemployment insurance off the weekly-wage analysis sheet and treat it as a straight overhead charge. Although this is an item which definitely varies in proportion to the labour employed, it is sufficiently accurate to deal with it as an overhead charge, whereas putting it down in the direct labour oncost may cause confusion because all the other items are actual wages paid.

The figures which the accountant shows on the monthly report sheet against the items, "Factory Maintenance," etc., are not, of course, merely the labour transfers. They are the total expenditure under these headings, including the labour transfer. All unproductive labour not transferable to specific items is entered as a whole on the monthly report against "Indirect Labour." This item may include salaries paid to works staff, such as foremen, rate fixers, inspectors, or, preferably, such salaries should be shown as a separate item.

Overtime

The usual working week is forty-seven hours, comprising eight and a half hours each day from Monday to Friday inclusive and four and a half on Saturday morning. Operators called upon to work for more than eight and a half hours on a week-day or for more than four and a half hours on Saturday expect to be paid at an extra rate for this overtime. If the employer belongs to his appropriate employers' association he will automatically apply the rules agreed between his association and the trades unions. For instance, the agreement between the Engineering and Allied

Employers' National Federation and the A.E.U. stipulates that overtime worked either before or beyond the normal working hours in any one day shall be paid at the rate of time and one-third for the first two hours and time and a half thereafter. A male worker can, if necessary, be instructed to work through his meal hour and take it later and no extra payment is due to him for this, provided he still does not work more than eight and a half hours in the day.

The employer is under no sort of legal obligation to apply these rules unless perhaps he has contracts which include the "Fair Wages Clause," but it may be taken that no employer can avoid paying the rates laid down by his appropriate association even if he does not belong to it. So far as the fair wages clause is concerned it is a curious fact that, although this invariably appears in Government contracts, there is, nevertheless, no definition or statement as to what is meant by it. Neither the Government department issuing the contract nor any other department will accept the responsibility for telling the employer what a fair wage is. The generally accepted standard is, therefore, that agreed between the employers' association and the trade unions corresponding to the industry in question.

In the case of female workers and young persons (that is, below the age of eighteen) there is a number of strict rules laid down by Act of Parliament which, while stipulating nothing in regard to payment, forbid the working of overtime beyond certain limits, and also the working of more than four and a half hours without a break. The manager who is not absolutely sure of the legal position should, therefore, always consult H.M. Factory Inspector for his district before arranging for any female workers or young persons to work anything but the standard working hours. Quite apart from avoiding any possibility of breaking the law, he will find the inspector a most useful person to advise him in the matter.

The various agreements made do not generally affect staff, i.e. those paid a weekly salary, but apply only to hourly-paid workers. The legal requirements in regard to women and girls, however, affect all employees, no matter how they are paid. It is sometimes forgotten that to cause a typist to work beyond four and a half hours without a break may be just as illegal as it would be in the case of an operator.

Desirability of Overtime

Assuming that all trade union agreements and legal requirements are understood and complied with, there still remains the

question of the desirability of working overtime at all. It will probably be agreed by most works managers of experience, and especially by those who have, over a period of years, taken the trouble to compile statistics, that overtime working is undesirable. There is not much doubt that working beyond eight and a half hours per day does not result in a proportionate increase in output, especially if it extends over a long period. Of course, in unusual circumstances or if actuated by some special stimulus, an operator may very likely disprove this rule, but no matter how powerful the stimulus, it cannot be expected that this will be the case over an extended period. Certainly working overtime each evening and then Saturday afternoons and Sundays for any length of time not only seriously reduces the efficiency of the operator but, if he or she is seriously attempting to keep up the pace of normal work, will probably produce a break-down in health. Consequently, whatever the circumstances, operators should be given at least one complete day's rest per week, preferably Sunday.

An interesting point in this connexion is the operator's outlook. The original object of the trade unions in making the various agreements with employers' organizations to pay extra rates for overtime working was to discourage overtime, both because of its undesirable effects on the operators and also to cause employers to engage more operators and thus reduce unemployment. However, and quite apart from the state of unemployment which may exist, the majority of operators prefer to work a certain amount of overtime because of the extra wage it produces. In fact, if they are in a strong enough position they often demand to work overtime, and, other things being equal, will take a job where overtime is the rule rather than one where it is exceptional.

Taking everything into consideration, the best rule for the employer probably is to put operators on overtime only for short periods when an unusual set of circumstances arises, and never to do it over an extended period where it is possible to engage extra operators.

Shift Work

In some trades as, for example, the manufacture of glass, where the processes are highly mechanized, and therefore the operators are not much more than machine minders, it is often usual to work shifts. A common system is the three eight-hour shifts in twenty-four hours so that the plant works continuously. In factories where such shift working is the habitual practice, no particular difficulty is

generally experienced in obtaining operators who will work such shifts, but, here again, various agreements stipulate extra rates to be paid, and there are also legal requirements applying to females and young persons.

In factories which do not usually work on the shift system, considerable difficulties may be experienced in getting operators to go on to shift work, especially if the state of trade generally is good so that there is little unemployment. The objection to the three eight-hour shift system is more pronounced than to the two-shift system, i.e. a day shift of, say, ten hours and a night shift of ten or perhaps twelve hours for five nights only. The operators advance all sorts of objections, such as the difficulty of obtaining public transport at the hours required, but the real trouble is that the three-shift system means less working hours per week, no possibility of overtime and therefore a smaller total wage. This difficulty is especially pronounced where overtime working has been in force for a period, and the management is attempting to increase the output by changing over to a shift system.

The fact remains, however, that the three-shift system is definitely the most efficient from all aspects and therefore, even if it delays the step-up in production, it is better to change straight from normal day work to two eight-hour shifts and then later to three eight-hour shifts than to go through an interim period of day shift with overtime which may well render the change to eight-hour shifts impossible because of opposition from the operators. Of course, all that has been said on this subject is influenced by the particular class of operator in question. For instance, those working at high speed on a bonus system are the most likely to show a reduction in efficiency from working overtime, especially if the work is physically hard or, equally, if it imposes a considerable mental strain. On the other hand, highly-skilled operators not on any sort of bonus system, such as toolmakers, appear to thrive on overtime because they can quite easily adjust their speed of working so that no matter how many hours they work in a week, they only produce about the same amount. However, there are certain classes of operators, such as shop labourers or operators of large machine tools taking a long time to do each piece, where the rate of actual work is so low that anything extra by way of overtime can scarcely make much difference.

Chapter XII

OVERHEADS

At the outset it is necessary to draw a distinction between overhead expenses and overhead charges. Overhead expenses are all items of expense except direct material, direct labour, and expenditure on the capital account. The overhead charge which is made against each job is made to yield a contribution to overhead expense, and the art is to arrange matters so that at the end of the year the total overhead charges cover the total overhead expenses involved.

Fixed and Variable Overheads

Within reasonable limits the amount of money spent on direct materials and on direct labour varies in proportion to the amount of work produced, but quite a different state of affairs exists in regard to overhead expenses. A large proportion of these expenses is fixed, and although to some extent the balance is variable, it varies not so much in proportion to what is being *produced* as in proportion to what is being *attempted.* Such items as rent, rates and taxes, depreciation, and staff salaries may be regarded as fixed, since, unless something unusual and deliberate is done to effect a reduction, they will remain steady throughout the year. Items such as power and maintenance, repairs, and works salaries can to some extent be varied in proportion to the amount of work going through the factory, but very largely they will depend on what the factory sets out to do rather than what it achieves in the sense that, if for some reason the output falls off, expenditure on such items will probably not fall appreciably unless some active steps are taken to effect a reduction. For instance, if it is anticipated that the falling off is temporary and therefore no deliberate cuts are imposed, expenditure on these items will remain fairly level or might even rise because of steps taken to boost up production again. If, however, the management is obliged to contemplate a lengthy or permanent reduction in output, these expenses will have to be cut down. It is clear that they will then be reduced because it is intended to produce less—they have not fallen because less is being produced. Such items as freight and cartage, consumable materials, and consumable tools will fall to some extent automatically if the output, and particularly if the number of workers, are reduced, but by no means in direct proportion and therefore it is safer to regard

these also as coming into the class of expenses "reducible by intention," and to disregard any automatic variations which may take place.

Direct Labour Oncost

Before proceeding further, it might be advisable to deal with certain items which may be regarded by some as properly chargeable to overhead expenses but which, since they are intimately concerned with direct labour or vary in direct proportion to the number of workers employed, should more correctly be dealt with not as an overhead but as a separate addition to the basic direct labour. These are—

Lost Time.
Holiday Reserve for Hourly Workers.
Overtime Increment.
Labour in Scrap.

The item "Lost Time" has already been dealt with. The "Holiday Reserve" is the 2 per cent which must be set aside each week to cover the week's holiday with pay which is now usually paid to hourly workers. In dealing with this item it is important to note that the direct workers must earn the holiday pay given to the indirect workers. In whatever manner a record is shown of the amount of wages paid out to indirect workers, and from which therefore the appropriate sums are transferred, the holiday reserve would probably be kept separately. From this it follows that if a sum of money representing wages paid to indirect workers is transferred to overheads or is in some way related to expenditure on direct wages, this sum would not include the money placed into the holiday reserve on account of these workers. Thus, if the total basic wages paid to indirect hourly workers is, say, 50 per cent of the basic wages paid to direct workers, the holiday reserve must be taken as representing 3 per cent on the direct wages bill. The same principle applies to the employer's contribution in respect of national health and unemployment insurance, and any similar amounts which might be contributed to such things as workers' sick funds or pension schemes, etc., if they are dealt with in this way.

The overtime increment is the extra amount paid for overtime working, and does not include the amount paid at the normal hourly rate for overtime working. It would also include the extra paid for working on Sundays or holidays, or for shift work. In the latter case, for instance, where an operator is paid forty-seven hours for

working, say, forty-five hours because the forty-five hours is made up on shift work, the whole of the extra two hours' pay would be regarded as increment. Where an operator works two hours overtime at time and a quarter, the increment is one-quarter of two hours' pay.

Now the overtime increment is paid to the worker each week no matter whether he is classed as direct or indirect and, therefore, when an amount appears in the wage analysis as being paid to direct operators, it includes the overtime increment paid to them. It is, therefore, correct if the overtime increment paid to the whole of the workers is reduced to a percentage on the wages paid to all the workers.

The method of arriving at the cost of "Labour in Scrap" month by month is dealt with elsewhere, but it is necessary to make clear why this is put into the direct labour oncost. A consideration of this and of the other items under this heading shows that they are all amounts which are automatically included in the direct labour cost established by the cost clerk. Consequently, therefore, they must be included in the direct labour oncost, and not in the overhead so that the estimate shall line up with the cost.

In respect of the above items, therefore, the following percentages might be obtained—

	Per cent	
Lost Time	10	
Holiday Pay Reserve	3	
Overtime Increment	2	
Labour in Scrap	5	
Total	20	per cent on basic direct labour.

This total percentage, which will be referred to as the direct labour oncost, should be applied to the basic direct labour cost as a separate item before dealing with overhead charges when a cost estimate is made up. It is suggested that all indirect labour should be regarded as an overhead expense. It ought not to be regarded in the same light as the above items because, when expenditure on direct labour increases, every attempt should be made to prevent an increase in indirect labour and, when direct labour falls, an automatic fall in indirect labour will not result.

Fixing of Overhead Charge

At the beginning of each financial year, therefore, or at other times if appreciable fluctuations in output are experienced or

anticipated, the total overhead expenses should be estimated. The usual method is, then, to make a corresponding estimate of direct labour cost and work out the ratio of overhead expenses to direct labour. Suppose, for instance, it is estimated the total overhead expenses will be £48,000 and the total direct wages £24,000, the overhead ratio is 200 per cent on the direct labour. It should be noted that the amount £24,000 includes the direct labour oncost. Taking this at the figure 20 per cent, it means that the basic direct labour anticipated is £20,000.

This overhead percentage is then made the overhead charge in cost estimating so that, provided the total amount spent on actual productive labour is not less than £20,000 in the year, and the direct labour oncost does not exceed 20 per cent, the total amount of money required to meet the estimated overhead expenses will be obtained by the end of the year.

This method of dealing with the overhead charge has the merit of being simple and universally adopted, but it is nevertheless open to several grave objections. The first is the curious fact that an enormous number of people seem to forget completely that this percentage is only a convenient way of dealing with something real, and allow themselves to fall into the error of regarding the percentage itself as something real. Perhaps this is rather an exaggeration, but it is an undoubted fact that many men occupying positions far higher than the ordinary cost clerk or estimator use the overhead percentage or talk of it in ways which indicate quite clearly that they have completely forgotten what it really means.

Overhead as Percentage

The overhead percentage figure means nothing in itself and cannot therefore be said to be either high or low. Two factory managers comparing notes might touch on the subject of overheads. If they know each other very well, one may tell the other proudly that his overheads are only 150 per cent, but the other, in admitting 200 per cent, claims with genuine conviction that he always likes to see a high overhead percentage because it indicates an efficient factory. The pride of the one is probably as unjustified as the conviction of the other. Even the percentages ruling in two factories producing similar articles cannot be compared unless they are similar in regard to equipment, and especially unless they work at the same material consumption percentage.

The second drawback is that when steps are taken to reduce the labour cost on a job by employing cheaper labour, the cost

clerk automatically reduces the overhead charge, although the overhead expenses may not have fallen. Suppose the factory cost of an article is 100 pence, arrived at as follows—

		Pence
Material		46
Basic Direct Labour	15	
Direct Labour Oncost 20%	3	
	—	18
Overhead at 200% on Direct Labour		36
Total		100

and as this is found to be too high, the labour cost is reduced by employing cheaper labour, for instance girls, on some of the operations. The cost estimator might then write down—

		Pence
Material		46
Basic Direct Labour	10	
Direct Labour Oncost 20%	2	
	—	12
Overhead 200% on Direct Labour		24
Total		82

showing a very attractive price reduction. One only has to imagine the extreme case where this is the article produced in a single-product factory to see that at the end of the year the amount of money recovered out of overhead charges will be only 67 per cent of the overhead expenses, and the other 33 per cent will be a loss or, at any rate, will make a serious hole in the profits. Of course, one can hardly imagine this happening in a single-product factory, but what actually does happen in a multiple-product factory is that foremen are constantly urged to reduce labour costs, and the subsequent action of the cost estimators means that at the end of each year they are liable to show a loss in regard to overhead recovery. Each year, therefore, the tendency is for the overhead percentage to rise, and as it is generally unaccompanied by any reasonable explanation, the foreman naturally feels somewhat disgruntled.

Departmental Overheads

In a multiple-product factory divided into shops, it is quite usual to have different overhead percentages for different departments. Unless the factory is of considerable size, it is doubtful whether the cost of this subdivision is justified. If correctly applied, that is, if not only the true overhead expenses incurred in a department

or shop but also the true wages bill in that shop are equated, it is found that the figures have a tendency to balance. One would expect, for instance, the overhead expenses in a machine shop to be higher than in a small armature winding shop, but the chances are that the machine shop will employ a relatively high proportion of skilled male workers so that the wage bill will also be high, whereas the winding shop may employ only female workers, resulting in a considerably lower wage bill. One of the drawbacks of the system of separate overhead percentages is that it may lead thoughtless people to divert work from one department to another where it may actually be done with less true efficiency because, on paper, a saving is made due entirely to a lower overhead percentage. If this is done to any extent, overhead recovery as a whole will fall short of overhead expenses.

Another criticism of the overhead percentage system is that it is too inflexible. For instance, it is clear that if a factory running at a steady load and paying its way is offered an important contract which would have the effect of increasing that load over a considerable period, it could afford to accept the contract at a price including a lower overhead charge than normal. The additional work would probably not increase the overhead expenses appreciably, while the necessary overhead charges are already being levied on existing output. It would, however, be outside the scope of the ordinary cost estimator to calculate just what reduction in overhead percentage is allowable in such a case and, if it is referred to one of the higher executives, he will very likely make no attempt at a serious calculation but will give an arbitrary decision and hope for the best. Even if the additional work involves overtime or night work, it could still be taken at a lower overhead charge and yet the ordinary percentage system will actually show a higher price under such circumstances. The increment arising from overtime or night work will first inflate the labour charge and, since the overhead percentage is put on the whole, an inflated overhead figure will also appear, giving a total cost probably far in excess of the price at which the contract in question can be obtained.

The unimaginative or timid manager might either fail to secure the contract on price or press for extensions to plant to enable it to be done in normal working hours, which would involve a quite unjustified additional capital expenditure. The bold manager, however, would apply common sense and cut the estimate which is prepared according to the standard formula, but he would probably wish he had a reasonable method of calculating what he ought to do.

Overhead on Time Basis

Many of these objections can be eliminated by making the overhead charge a function of labour time instead of a function of labour cost. In this case the basic estimate is not what is likely to be spent on wages, but what number of operator hours are likely to be employed. This can be done whatever wage payment system is adopted, but it can be explained simply by reference to the points values system.

Taking again the instance where the overhead expenses are estimated at £48,000 for the year, the estimate in regard to basic labour points as an alternative to basic labour cost might be 23,000,000 points. The total figure for overhead expenses divided by the total operator points gives a figure of 0·5 pence per point; that is to say, in this case the overhead point value is 0·5 pence. The cost estimator would then deal with the estimate given as follows—

		Pence
Material		46
Basic Direct Labour, 72 points at 0·208 pence per point	15	
Direct Labour Oncost 20%	3	
		18
Overhead, 72 points, at 0·5 pence		36
		100

this being the case where the class of operator coincides with the average rate being paid in the factory. Assuming now that a cheaper operator can be put on the job, the alternative system would yield the following—

		Pence
Material		46
Labour, 72 points at 0·14 pence per point	10	
Direct Labour Oncost 20%	2	
		12
Overhead, 0·5 × 72 points		36
		94

or, to move the other way, assuming that the labour cost is inflated by overtime or shift work or by the employment of more expensive operators, the comparison would then be—

		Pence
Material		46
Direct Labour, 72 points at 0·25 pence per point	18	
Direct Labour Oncost at 20%	3·6	
		21·6
Overhead charge, 0·5 pence × 72 points		36
		103·6

The examples show the advantage of relating overtime charges to time, although a considerable courage is required to change over from one system to the other.

Advantages of Time Basis

Another feature of the time system is the ease with which a cost estimator may adjust his basic figure with confidence. The figure originally set for the overhead point value, whether it be for the whole factory or for one particular shop, can be given as corresponding to a certain number of operator hours. If the production control section supplies to the cost section the actual load in man-hours each month, the figure for the overhead point value can be adjusted quite simply.

An interesting illustration of this point is provided by the case where it is decided to increase the percentage of female workers in a factory, or where it is decided to introduce a class of work which will employ a higher percentage of female labour than the average. As the percentage of female workers is increased, the average wage rate will fall. If a general overhead is established as a percentage on labour from the figures for the previous year, then during the year in question the overhead charge will gradually become inadequate to cover overhead expenses. To put it another way, as the percentage of female workers is increased, the overhead charge percentage should be increased correspondingly. If, however, an overhead point value is used, then the substitution of female labour has no effect on it. Generally speaking, women who are brought in to work previously done by men will do it in the same time; therefore the various piece-work times or point values already established can stand. The result is that the overhead charge in £ *s.* *d.* on a particular job remains the same, even though the labour cost has been reduced by the substitution of female workers.

Considering now the case where a class of work is introduced in which the percentage of female workers is higher than the average, it will be seen that, using the overhead percentage method, the low labour cost of the new business automatically means that it is charged with a low contribution to overhead expenses. If it were possible to work out exactly what overhead expenses are involved in the job, it might well be found that it is not carrying its fair share. Conversely, the company's original business on which a large proportion of men is employed would be found to be carrying more than its fair share. If, however, the overhead charge is based on the time which operators take to do the work instead of on the

wage they are paid, then those jobs which employ a high proportion of female workers contribute their fair share towards the overhead expenses, while the cost of manufacturing in sections where the men are in the majority is not inflated.

On page 136 appear the various items which go to make up the overhead expenses. There is, of course, no uniformity in regard to the descriptions given to these items, but the reader will not find it difficult to decide which descriptions used in his own organization correspond to those given in the example. Also, depending on the circumstances, it may be necessary to include other items, or some of those which are shown separately may be combined. However, something might be said in regard to works salaries and indirect labour.

Works Salaries

This item comprises all wages paid to staff employed in the factory itself, provided they are not on actual production. That is, foremen, inspectors, etc. If there are any employees who are paid a definite weekly wage instead of an hourly rate, although on definite production, their wages should not be included under this heading but in productive wages. The line of demarcation is whether their time can be booked against definite jobs. The fact that workers on actual production are usually paid by the hour is a useful indication, but does not itself constitute a distinction for this purpose.

Indirect Labour

In any factory there is usually a considerable number of workers who are paid an hourly rate but who are not on direct production. For instance, labourers, cleaners, store-keepers, and machine setters. These men book their time as indirect labour by the method described (page 112). In addition, however, there will be many occasions on which an operator usually employed on direct work is temporarily instructed to do something indirect. A capstan operator may set up his own machine, in which case the time which he spends in setting up may be booked as indirect labour, but the time spent in doing the job afterwards, against direct labour.

The guiding principle is that the instructions laid down in the factory regarding time booking must line up with the rules followed by the estimating section, so that there is no possibility of any labour time being omitted from an estimate. It will be noted that the heading, "Instructions and Setting," appears on the wage analysis sheet, page 113, both under the heading "Overheads" and under

"Lost Time." The one is time which is normally allowed for, and the other for time in excess of the normal allowance. Depending on the degree of skill involved, new operators should be given a certain time to learn a job. This time is booked against the order corresponding to "Instructions" in the section "Overheads." If the operator proves to be exceptionally slow and takes longer than normal to learn the job, then the extra time should be booked against "Instructions" in the section "Lost Time." Again, the official setters (including operators setting up their own machines) and instructors should be sufficient to deal with all setting and instruction, but there may be cases where a direct operator is temporarily used to do setting or instruction in place of a salaried man absent through illness or, in addition to the ordinary staff because of an unusually high percentage of slow learners. Such an operator would book his time against the order corresponding to "Instructions and Setting Lost Time," because he ought to have been on productive work. Another important item is the cost of the rectification of rejects. *All* times booked on this account must be recorded as indirect labour, and thus transferred to overhead expenses, but also where a particular rectification job is of important dimensions so that it is booked against an individual "J" order, the cost returned on the order can be booked against the main contract as an item of true cost. Strictly speaking, the overhead percentage applied should then be adjusted to leave out this charge, but since this adjustment would be very slight, it may be neglected.

Chapter XIII

BUDGETARY CONTROL

It will not be disputed that if a factory is to be run efficiently, the general manager must have some system whereby he can watch progress in such a way as to be able to take action, when required, to keep the various factors involved under strict control. The essentials of the system are that it should be as simple as possible without sacrificing effectiveness, that the statistics which it demands should be accurate and easily understood, that these statistics should be available at regular intervals, and that the interval between the period to which the figures apply and the time when they are available should be short.

The control of wages has already been dealt with in detail, and it will be remembered that this is shown on a weekly basis. The figures thus made available enable the total spent on labour to be split and transferred to the appropriate accounts. It is convenient and reasonably satisfactory if the accounts as a whole are reviewed monthly and this means, therefore, that all labour expenditure transfers should be made monthly.

Monthly Report

So far as the internal work of the factory is concerned, there are many advantages to be derived from using thirteen four-week periods in a year instead of twelve calendar months. Unfortunately, however, this introduces complications when dealing with matters outside the factory. For instance, it will be found that the majority of suppliers invoice accounts monthly and therefore towards the middle of the year, when the end of the four-week period would come in about the middle of a calendar month, it would be very difficult to produce complete statistics including figures relating to outside purchases. For this reason, therefore, it is on the whole probably better to adhere to the calendar month.

At the end of each month, figures for all items of expense for the month, for the net productive labour after transfers have been made, and for material consumption should be produced. The addition of these items gives the total outgoings for the month. If this sum is subtracted from the value of the month's output a figure for a margin or deficit is arrived at which, to a very close approximation, differs from the net profit or loss made that month only by any

increase or decrease in the work in progress. It is questionable whether any attempt to establish the net profit more nearly is worth the trouble and the expense involved. Clearly there is no point in attempting it unless a reasonable degree of accuracy can be achieved. If, however, the cost office produce figures for the labour content in the month's output (including, of course, the direct labour oncost) and subtract this from the total expenditure on direct labour, the difference is the labour content in an increase or decrease in the work in progress. If this difference is mounted by the normal overhead charge and the total subtracted from or added to the margin, the approximate net profit is arrived at. Any profit which may be made when the extra work in progress is delivered, should be excluded. In the case illustrated, page 137, the labour content in the output of £21,253 was £4458 and, therefore, there was a reduction in the work in progress. The labour content in this decrease was £138 and, mounting this by 151 per cent, gives a total of £346. Subtracting this from the margin gives £1458 as the approximate net profit for the month. Since the total outgoings are appreciably increased in a five-week month, while the output is very little affected, it follows that the procedure described above will tend to show an increase in work in progress in a five-week month and a decrease in a four-week month, or, in other words, it will tend to produce an even monthly net profit, whereas the monthly margin fluctuates.

Labour Content

In order that this work may be done with the minimum of trouble, and therefore in good time for the monthly report, the cost office may arrive at the labour content in the output by applying the labour percentage shown in the factory cost corresponding to each item. These percentages should, of course, be revised each time the factory cost for a product is re-established. Since the cost office will have a considerable amount of work to do during the first half of the month getting out the statistics for the previous month, it will suit them to attend to the revision of factory costs during the latter half of the month. If these cost revisions are reasonably frequent, then the application of the percentages which they show for direct labour cost to arrive at the labour content in the output will be reasonably accurate. In order to complete the illustration, calculation of this item is shown on page 131 for the example to which the specimen monthly report and the other figures apply.

OUTPUT FOR MONTH OF MAY

Item	Output	Direct Labour %	Direct Labour Content
			£
A	3,500	16	560
B	4,000	19	760
C	6,000	24	1,440
D	4,000	24	960
E	3,500	20	700
F	253	15	38
	21,253		£4,458
		Actual Expenditure	4,320
		Labour in decrease in W.I.P.	£138

The suggested monthly financial report includes at the top a section for expenditure on the capital account. It will be noted that, in addition to entering the expenditure and the amount which has been sanctioned, an average figure for the depreciation which will be made against each item is also set down, so that each month the extra depreciation corresponding to the capital expenditure made during that month can be worked out, and this is carried down and added to the expenses against the heading "Depreciation." The direct material consumption figure may be available if a sufficiently elaborate system is set up, but, at the moment, it will be assumed that this is not considered worth the expense. If the forecast for the percentage material consumption is carefully drawn up, it will be sufficiently accurate to use this figure in arriving at the expenditure on material each month. Clearly, the accuracy of this figure will be considerably improved if the factory has a good order book, and if the various different products on the programme have approximately equal material percentages, so that if for some reason production falls off in one or goes up in another, the overall material percentage figure will not be appreciably altered. If, however, a stores control system is laid down which enables an accurate figure for the stock to be arrived at each month, the word "estimated" can be deleted.

Grouping of Expenses

The expense items are arranged in two groups. The upper group comprises those items which are considered variable by intention,

and these are added to show a sub-total. The second group are the items which must, generally speaking, be regarded as fixed. Thus, if the general trend of the figures shows that something must be done to reduce the overheads, the sub-total shows the total amount which can be attacked and, therefore, gives some indication of what can be expected to be possible.

Items such as rent, rates and taxes, insurance (other than national health and unemployment) and any special contributions such as might be paid to a joint research laboratory or to a head office for administration, etc., may actually only be charged to the factory annually or quarterly. The expected annual charge should therefore be divided into twelve amounts so that the correct proportion can be put down on the monthly financial report. Every three months or at whatever intervals it is possible, the actual definite amount charged to date can be put down so that the report figure is corrected.

The accountant should be able to produce the figures for the month by the 15th, or at latest the 20th, of the following month. The only item likely to cause any difficulty is the materials purchased figure, because of delays in invoices coming from suppliers. To some extent the books may be closed before all invoices are received and a round figure put in for the amount outstanding, but this must not be carried too far or an unanticipated rise in the stock may occur. It is recommended, therefore, that this should be done in order to provide figures in good time, but at each third month the issue of the monthly report sheet should be delayed until all purchase invoices have been received so that the figures are brought strictly into line. A figure for orders placed by the buying department should also be obtained and entered on the sheet. This shows whether the buyer is committing the factory to expenditure beyond the budget or, conversely, what might delight the accountant but would disturb the general manager, it would show whether he appears to be ordering supplies of material inadequate to keep production going.

Value of Separate Statistics

At this stage it can be seen clearly how valuable it is to have a separate selling organization responsible for stocks of finished materials. If this is done, the output value figure for the factory is the price paid to the factory for its monthly output. The position is not complicated by obliging the factory to hold finished materials in stock. If the factory is only allowed to show as output the goods

actually delivered to customers, then, due to fluctuations quite outside the scope or control of the factory, a monthly report may be rendered largely useless, at least so far as the figure for the profit or loss is concerned. A comparison between the form of monthly financial report recommended and similar forms given in books which deal with the control of a factory in which sales are not separated from manufacture, shows to what a tremendous extent statistics are simplified when this subdivision is made. It is not proposed here to make any suggestions in regard to the way in which the separate statistics which would be required for the sales department should be drawn up, but clearly if they are completely separate from the figures produced in regard to the factory, they can be presented on an entirely different basis drawn up to suit the requirements of the sales organization which may be very different from those of the factory itself. The separate statistics drawn up by the sales department would be mainly concerned with the movement of stocks of finished materials, and would enable appropriate measures to be taken in regard to these stocks quite independent of what is going on inside the factory.

In considering these separate statistics two outstanding factors emerge. On the one hand, to ensure efficient production it is most important that the factory output should be continuous and smooth, while, on the other hand, violent increases in factory output simply cannot be arranged and violent decreases are very serious. On the sales side, however, a violent increase in sales can be arranged if necessary by various expedients from engaging more salesmen to reducing prices. Also, on occasion, if the market conditions demand it, a drop in sales may be contemplated with equanimity, but if the sales organization were not separate from the factory, and therefore attempts were automatically made to reduce the output to correspond to reduced sales, or if the output were kept up and the statistics for the factory reflected an increase in factory stocks, they would not show the factory efficiency, which is the object here intended.

The Budget

Although the figure of margin or deficit shown by each set of monthly figures is valuable, effective control requires more than this. There must be some comparison available against each item on the sheet, so that individual control over each one may be exercised. Otherwise such simple things may occur as a dangerous increase in one item which passes undetected because of an

accumulation of small reductions in several other items. Also, unless individual comparisons are available, there is no immediate starting point for an investigation when the figures as a whole show a deficit or an unsatisfactory margin.

A common method is to compare with a previous period. This may be done either by comparing each month with the previous month or by comparing the month with the corresponding month of the previous year. The first is unsatisfactory because there are generally seasonal fluctuations, and the fact that the one month is better than the previous may be good news or bad, depending on how bad the previous month was. The second is more satisfactory, but does not show with sufficient accuracy the "trend" of the business. Consequently, a more satisfactory idea is to use the moving annual total method (M.A.T.). In this, the difference between the month under review and the corresponding month of the previous year is added to or subtracted from the total for the previous year each month in succession. For instance, if the production for the previous year was £120,000, for the first month of the current year it was £12,000 and for the corresponding month of the previous year £10,000, the M.A.T. figure becomes £122,000, and so on. This system irons out large fluctuations, and a curve drawn through the points month by month shows very effectively the trend of the item which it represents.

Budgetary Contol

However, the method of controlling a business by comparing results with what has been done in the past is not entirely satisfactory. It is rare that a business is expected to remain steady. Usually some expansion is anticipated, but there may be times when the board simply cannot avoid facing a reduction. Consequently it is better to prepare at the beginning of each financial year a forecast or budget showing what the business is expected to do that year, and to proceed by comparing the results each month with the forecast. This is what is known as "Budgetary Control."

The general manager is strongly recommended to draw up the budget himself. This may involve some considerable work which he would feel inclined to pass on to the accountant, but an intelligent forecast essentially calls for precisely those qualities which distinguish the general manager. That is to say, it demands on the one hand a proper appreciation of past accounts, while on the other an assessment of the factory's potentialities in regard to output, a knowledge of the company's policy and of his own and the directors'

ideas in regard to development which only the general manager can possess. Also the work involved will provide him with an excellent exercise and will ensure that he knows as much about the business as he should.

The forecast should show first the anticipated output for the year valued in terms of the prices which the factory will obtain. That is, it excludes the gross profit which must be made by the sales organization, but should include a small margin of net profit above the bare factory cost so that whether run as a separate company or not, the factory can show a dividend on the capital it uses. The material consumption, the direct labour expenditure and the overhead expenses item by item should next be estimated. Having done this for the whole year, the totals should be divided into twelve parts in order to show what is expected for each month. If a rise or fall in turnover throughout the year is anticipated, this must be taken into account so that the twelve divisions of the total will not be equal. The turnover which is expected month by month should be written down, likewise the direct labour, and then everything possible should be done to regulate overhead expenses to conform to the turnover, but, of course, it is of no use to write down a figure which would line up with the turnover if it cannot be realized. In compiling the forecast the figures written against each item of overhead expense month by month must be what can be achieved with reasonable assurance.

A little consideration will show that if a rise in output throughout the year is expected, then a monthly forecast of one-twelfth of the total expenses for the year would probably show a favourable comparison with actual expenses during the first few months, which would be quite misleading. Conversely, if the forecast has to take into account a turnover which will gradually fall during the year, an even division of estimated expenses will not show with sufficient force the reductions which must be effected during the later months.

Four-week and Five-week Month

Assuming that a true monthly statement has been decided on rather than one covering four weeks, it is necessary to distinguish between a four-week month and a five-week month. In preparing the budget, therefore, two sets of figures are required for items such as wages and salaries, the one being $\frac{4}{52}$ of the total and the other $\frac{5}{52}$. When the monthly report sheet is made out, the accountant must show at the top whether the month in question has four weeks or five and then he should enter in the budget columns the

ESTIMATED OVERHEAD EXPENSES

	Year	4-week Month	5-week Month
	£	£	£
Works Salaries	7,800	600	750
Indirect Labour	9,000	692	865
Consumable Materials	2,500	208	208
Consumable Tools	3,000	250	250
Experimental	2,000	167	168
Maintenance and Repairs	4,000	333	333
Packing	750	62	62
Freight and Cartage	2,500	208	208
Stationery	500	42	42
Telephone and Postage	1,000	83	83
Insurance, National Health, and Unemployment	1,500	115	145
Water, Power, Gas, and Fuel	3,500	292	292
SUB TOTAL	£38,050	£3,052	£3,406
Staff Salaries	10,000	800	900
Rent, Rates, and Taxes	4,000	333	334
Bank Charges	100	8	8
Drawing Office	3,000	240	270
Administration	4,000	333	334
Audit	150	13	13
General Expenses	5,000	417	417
Insurance, Buildings, and Stock	1,000	83	83
Depreciation	4,450	371	371
TOTAL	£69,750	£5,650	£6,136

FINANCIAL REPORT FOR MONTH OF MAY—5 WEEKS

	Depreciation Rate	This Month	Depreciation C./D.	Expenditure to Date	Sanctioned to Date
CAPITAL EXPENDITURE	%	£	£	£	£
Buildings and Plant	10	500	50	500	500
Factory Equipment and Tools	25	150	75	300	1,000
Office Equipment and Furniture	100	25	25	25	100
		£675	£150	£825	£1,600

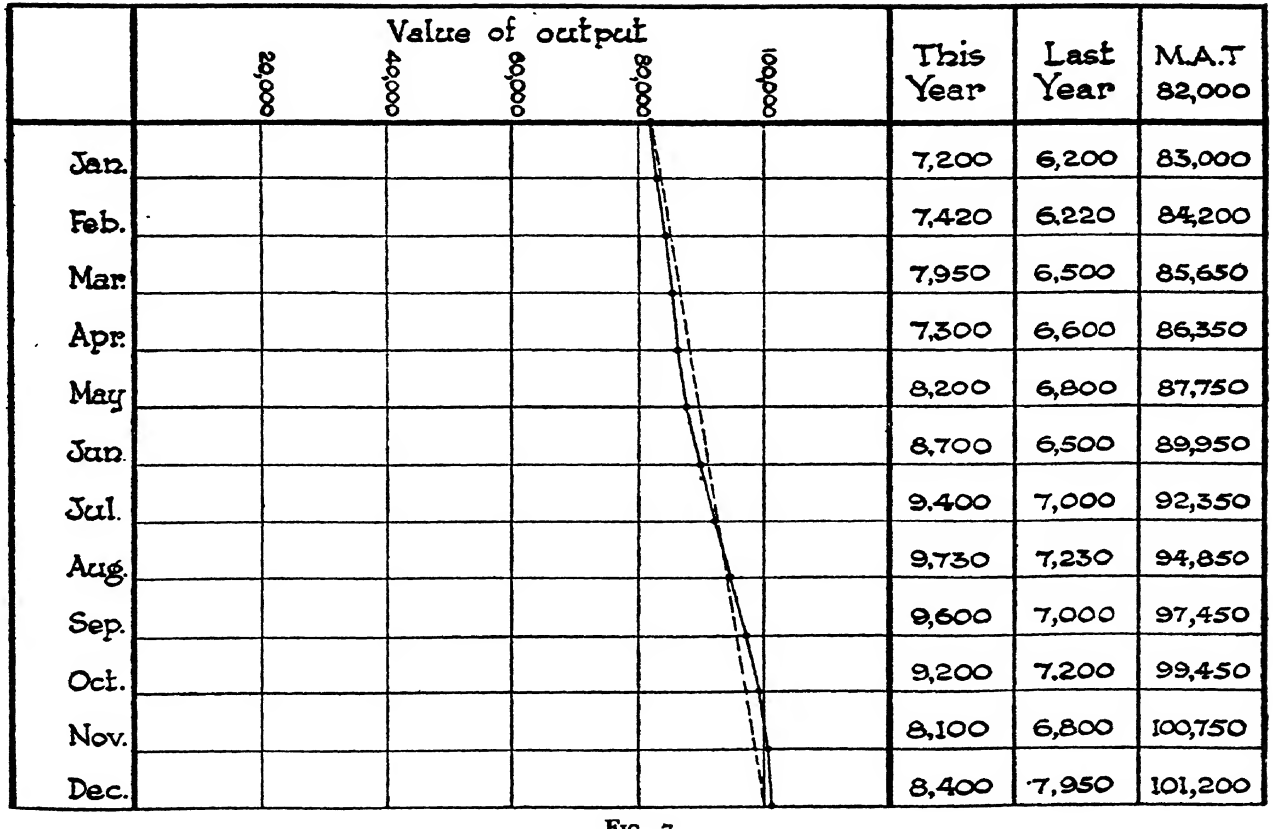
	This Month	Budget	To Date this Year	Budget to Date
	£	£	£	£
Materials Ordered	8,530		48,400	
Materials Purchased	7,420	8,000	43,270	40,000
Estimated Material Consumption	£8,870	£8,333	£45,200	£41,665
Direct Labour	£4,320	£4,450	£19,120	£19,550
EXPENSES				
Works Salaries	740	750	3,256	3,300
Indirect Labour	850	865	4,012	3,806
Consumable Materials	215	208	1,120	1,040
Consumable Tools	280	250	1,400	1,250
Experimental	140	168	700	833
Maintenance and Repairs	372	333	1,520	1,666
Packing	48	62	248	312
Freight and Cartage	180	208	870	1,040
Stationery	65	42	312	210
Telephone and Postages	90	83	422	416
Insurance, National Health, and Unemployment	141	145	618	635
Water, Power, Gas, and Fuel	320	292	785	1,460
SUB TOTAL	£3,441	£3,406	£15,263	£15,968
Staff Salaries	884	900	4,020	4,200
Rent, Rates, and Taxes	334	334	1,666	1,666
Bank Charges	8	8	42	42
Drawing Office	284	270	1,314	1,260
Administration	334	334	1,666	1,666
Audit	13	13	62	62
General Expenses	428	417	1,964	2,082
Insurance, Buildings, and Stock	83	83	416	416
Depreciation	450	371	1,700	1,860
TOTAL	£6,259	£6,136	£28,113	£29,222
VALUE OF OUTPUT	£21,253	£20,000	£108,220	£100,000
MARGIN	£1,804	£1,081	£15,787	£9,563
APPROXIMATE NET PROFIT	£1,458	£1,081	£12,100	£9,563
ORDERS RECEIVED	£18,750		£114,740	

corresponding figures. The important point to note is that, while the difference between a four-week and a five-week month has a considerable effect on the expenditure on wages, and although, to a less extent, a still not inconsiderable effect on the expenses, it will probably not make much difference to the material purchases, the material consumption, or the output if material is invoiced daily as delivered. Consequently it follows that the budget would anticipate a larger margin in a four-week month than in a five-week month. Thus, in the example to which the various figures given on page 137 relate, the estimated margin for a four-week month is £2467, while for a five-week month it is £1081. It will be seen that the items of expense are compared with the budget for the month and with the budget for the period from the beginning of the financial year to the date of the report. Figures for the M.A.T. are not given on this report since, as already suggested, these are better shown graphically, Fig. 7, and it is felt that the number of figures given on the report should be kept down to a minimum.

M.A.T. Curves

A chart should then be prepared for each of the items, material purchases, material consumption, direct labour, overhead expenses, and turnover or output, on which is plotted the M.A.T. If the material consumption is estimated, there is not much point in producing the M.A.T. for it. A line should be drawn across each chart at the outset connecting the point corresponding to the previous year's figure to the point corresponding to the anticipated figure for the year in question so that, as the M.A.T. curve is plotted, it can be seen immediately whether it lies above or below the line representing the forecast. It is probably unnecessary to draw charts for each item of expenses, as control of these can be exercised from an examination of figures alone. Control of the whole factory can then be exercised by the use of the monthly financial report, and the M.A.T. charts combined with the weekly wages analysis and an output analysis.

The forecast for the material consumption should be arrived at from a detailed analysis of the costs or, where these are not yet available, the estimates for the products on the order book, and those for which orders are anticipated, combined with a review of the figures for previous years. In a simple case, where there is an entirely separate sales organization placing stock orders against an annual programme, a very accurate figure can be estimated. In



	This Year	Last Year	M.A.T 82,000
Jan.	7,200	6,200	83,000
Feb.	7,420	6,220	84,200
Mar.	7,950	6,500	85,650
Apr.	7,300	6,600	86,350
May	8,200	6,800	87,750
Jun.	8,700	6,500	89,950
Jul.	9,400	7,000	92,350
Aug.	9,730	7,230	94,850
Sep.	9,600	7,000	97,450
Oct.	9,200	7,200	99,450
Nov.	8,100	6,800	100,750
Dec.	8,400	7,950	101,200

FIG. 7

more difficult cases, where the items which will comprise the output are known definitely for only a few months ahead, there is not the same degree of certainty. Nevertheless, it is surprising how very accurate the forecast can be once the general manager has had experience in drawing it up.

Work in Progress

One important item is the distinction between raw materials and work in progress. The stock figure entered on the trading account at the end of the year should be split into actual raw material (including, of course, components bought in finished) and work in progress, so that if the W.I.P. has gone up or down, the labour and overhead content can be taken away in computing the material consumption. The work in progress comprises not only material but also labour and overhead, and care must be taken to ensure that the labour and overhead contained in it is not put down as if it were material. For instance, if the value of the stock at the end of the year is £45,000 raw material and £5000 work in progress, compared with £40,000 raw material and £3000 work in progress the previous year, and it is found that of the two figures for work in progress the labour and overhead content is respectively £4000 and £2000, there is a difference of £2000 in labour and overhead content in the work in progress to be taken into account. Thus, if the material purchases for the year in question amount to £55,000, the stock increase of raw materials is not £7000 but £5000. The total amount of raw material still in the factory is £46,000, and therefore £50,000 must have gone out included in the products delivered.

From this it follows that if a steady increase in output during the year is anticipated there will probably be an increase in the work in progress and therefore the extra material, labour, and overhead content in this must be allowed for in the forecast. As a rough guide it may be taken that the work in progress will go up in proportion to the annual turnover and an examination of previous years' records, combined with the cost or estimate analysis already prepared to arrive at the material consumption percentage, will show how this anticipated increase in work in progress ought to be split under the headings material, labour, and overhead.

The increase in the work in progress does not affect the estimate of material consumption, but it does mean that a purchase of raw materials in excess of consumption and an additional expenditure on wages, must be contemplated in excess of the figures arrived at

by a pure analysis of the anticipated turnover, and these additions must be taken into account in the forecast.

However, in the case of a factory already operating at about full load and showing a reasonable profit as distinct from a new factory which is building up to capacity, it should be possible to hold the material purchases to a figure not exceeding the material consumption. Where, however, an increase in turnover is contemplated and since purchases must precede delivery of the finished product, a rise in output is accompanied by purchases rising some time in advance, and this also must be allowed for. This may conveniently be done by allowing a stock increase in proportion to the output increase, but, of course, this can be allowed only if the total stock is already considered a reasonable percentage of the turnover. In any case, the material purchases for the year, if different from the material consumption, should be estimated and the figure given to the buying department again, divided into monthly proportions, so that care can be taken to see that money in excess of that anticipated is not spent on buying materials.

Estimate of Direct Labour Expenditure

The estimate of direct labour expenditure should also be arrived at from an analysis of the estimates or, in the case of established lines, from the actual factory costs, combined with a review of actual labour expenditure as shown by the weekly analysis sheets. Incidentally, any difficulty in arriving at a reasonably close agreement between the figures derived from these two sources calls for an immediate check on the work of the estimating and costing section. Table B shows the estimates for material consumption and direct labour in an imaginary case where, for the sake of simplicity, it is assumed that the order book covers twelve months' work. Obviously, with a smaller order book the extent to which something similar can be arrived at will depend on whether corresponding assumed figures can be set down with reasonable justification.

The accuracy with which a forecast can be made when the order book is low is dependent on the extent to which the cost make-up of new orders will line up with the average. This is one reason why it is so strongly recommended that every attempt should be made to get orders where the material percentage does not differ much from the factory average material consumption.

Having arrived at the above figures from the analysis of cost estimates, they should be compared with those given by the weekly-wage analysis sheets in order to see whether the productive labour

thus estimated does, in fact, line up with that shown on these sheets over a reasonable period. Here, again, of course, due allowance must be made for a rising or falling output.

TABLE B

ANALYSIS OF ANTICIPATED TURNOVER

Item	On Order Book	Estimated Production	Material	Material Consumption	Direct Labour	Direct Labour Expenditure
	£	£	%	£	%	£
A	60,000	60,000	45	27,000	16	9,600
B	55,000	50,000	40	20,000	19	9,500
C	45,000	30,000	38	11,400	24	7,200
D	35,000	30,000	37	11,100	24	7,200
E	50,000	45,000	40	18,000	20	9,000
F	55,000	25,000	50	12,500	15	3,750
	£300,000	£240,000	41·7	£100,000		£46,250

	4-week Month	5-week Month	Year
	£	£	£
Turnover	20,000	20,000	240,000
Material Consumption	8,333	8,333	100,000
Labour	3,550	4,450	46,250
Expenses	5,650	6,136	69,750
Margin	2,467	1,081	24,000
Total Estimated Overhead Expenses			69,750
Total Expenditure			216,000
Estimated Net Profit			24,000

$$\text{Overhead Percentage} = \frac{6975000}{46250} = 151\%$$

Alternatively, Estimated Total Man-hours = 740,000

Overhead Point Value = 0·378 pence

Since the labour content in the work in progress is *deducted* from the total stock figure when arriving at the material consumption, it must be *added* to the total extracted from the output forecast in order to arrive at the total amount which will be spent on labour.

Estimate of Direct Labour Oncost

To finalize the direct labour figure for the budget, it is necessary to check back over the previous year's working, and to establish the figure for the direct labour oncost actually incurred. The item "Holiday Pay Reserve" is readily and accurately available. The accountant may not have a similar figure for the total paid in overtime increments, although no great amount of work is involved in keeping a separate record. However, the true average figure shown by the weekly labour analysis will be sufficiently accurate. In the case of "Lost Time" the total amount is arrived at from the weekly analysis sheets. There only remains the item "Labour in Scrap." In spite of all attempts, this last item, as arrived at month by month, may not be quite accurate and, of course, to some extent there may be slight inaccuracies in the others. If, therefore, the final total figure for the oncost is taken from the year's working, all these inaccuracies are taken care of.

The Table C is drawn up similar to Table B except that it shows the actual output for the past year instead of the forecast output for the current year. Against each item in the column "Basic Direct Labour Percentage" is given the percentage which the cost figures for the respective items show. It should normally be possible for a cost to be available for every item because, even in the case of those products which were not put into manufacture until the later months or even weeks of the year, there should be sufficient time to get the necessary returns to establish a cost in the interval which it takes to have the accounts audited and the trading account drawn up.

To the total arrived at in this way is added the labour content in the increased work in progress (or, of course, if there is a reduction, the amount is subtracted). From the trading account is taken the total amount spent on productive labour which exceeds the above by the oncost. Assuming the first three items of the oncost are correctly arrived at as described, the balance must be the "Labour in Scrap."

Having arrived at this figure a check should be made to see that it agrees with that used by the cost clerk and the estimator in arriving at the figures which are used to establish the direct labour in Table B for the forecast. It will be rarely considered safe to allow a lower figure to be used while, depending on the circumstances, it may be increased to provide a contingency.

Estimate of Overhead Expenses

In the case of overhead expenses, the estimate should be based mainly on past experience and figures. There will be certain items,

TABLE C

ANALYSIS OF ACTUAL TURNOVER

Item	Actual Output	Estimated Bare Material	Estimated Bare Material	Basic Direct Labour	Basic Direct Labour Expenditure
	£	%	£	%	£
A	65,000	41	26,650	14	9,100
B	45,000	36·5	16,450	15·5	6,975
C	32,000	34·5	11,000	20	6,400
D	25,000	33·5	8,375	21	5,250
E	48,000	36·5	17,550	16·5	7,925
F	28,000	45·5	12,750	13	3,640
	£243,000	38·2	£92,775		£39,290

	Material	Labour	Overhead	Total
	£	£	£	£
Opening Stocks	85,500	1,000	1,620	88,120
Purchases	100,000			
	185,500			
Closing Stocks	87,000	1,500	2,430	90,930
Material Consumption	98,500			
Estimated Bare Material	92,775			
Material Wastage	£5,725 = 6·2%			

	£
Total Direct Labour Expenditure =	46,000
Estimated Basic Direct Labour =	39,290
	£6,710
	= 17%

such as rent, where the answer is known right away. Such items as staff salaries can be quickly settled by reviewing what changes are likely to take place, and what increases in salaries will have to be given. This latter point is important. In any factory there is a considerable number of young people on the staff who must be given salary increases at regular intervals and, although increases to senior members of the staff may be postponed if the business does not justify it, it is impossible to retain junior members unless their

salaries can be increased as they become more experienced. If the estimate of the turnover is such that no increase in the salaries bill can be tolerated, then there is no alternative but to see what steps can be taken during the year to reduce the staff in order to provide a sum of money which can be devoted to the necessary increases to juniors. It is no use proceeding on the assumption that these increases can be avoided.

The items "Indirect Labour" and "Consumable Materials" can be estimated, the first mainly from an examination of the weekly wage analysis sheets, and the second by taking the percentage to turnover shown by the figures of previous years, with due regard to any new items on the programme which may call for extra consumable materials. There are, similarly, other items which can be taken as variable against turnover, but, as before stated, it is the anticipated turnover which must be taken, and it must not be assumed that these items will be correspondingly less if that turnover is not realized.

Depreciation

Depreciation, which ought also to be taken into account, can be closely estimated provided at the beginning of the year a clear statement is prepared in regard to capital expenditure proposed during the year. The major proportion of the depreciation will be the same as for the previous year. The amount for the year in question will only be greater if it is proposed to incur additional capital expenditure during that year. Thus, if it is proposed to purchase any new plant or, what is more likely, if it is proposed to make tools on the capital account, the depreciation which will have to be made in respect of these items at the end of the year can be set down at the beginning of the year when the sanction for this expenditure is obtained.

Writing off Jigs and Tools

Wherever possible, the cost of jigs, tools, and fixtures should be charged against the job for which they are required. That is, at the outset the cost of tooling up a job should be spread over the quantity ordered so that the tool cost is recovered as the items are sold. However, expenditure on these tools has to be met at the outset, and the delivery of the articles for which they are required may extend beyond the end of the financial year or the tools may be, in any case, required for production over more than one financial year. It is suggested, therefore, that such tools should at the outset

be regarded as capital expenditure, and the board should sanction an amount which is estimated as required for this item. At the end of the year all tools thus made against this sanction should be depreciated to the extent to which the order for the material on which they are used has been completed. For instance, if the cost of tooling up for an order for 20,000 articles is £1000, the factory cost of each article should be increased by 1s. to pay for the tools, but the £1000 expenditure at the outset should be regarded as capital expenditure. If by the end of the financial year 10,000 of these articles have been delivered, the tools should be depreciated by 50 per cent.

If this policy is objected to, then the manufacture of the tools should be treated exactly as the manufacture of the articles themselves, in which case the proportionate value of the tools at the end of the financial year must be taken into the work in progress and not into the raw material stock, because the major part of the tool cost is probably labour and overhead. If the amount of tool-making contemplated during the year is considerable, a separate item should be made of it in dealing with the turnover analysis which is made to establish the forecast for material and labour expenditure.

Chapter XIV

ESTIMATING AND COSTING

By "estimating" is meant estimating the factory cost of a product before it has been made and, by "costing," the reckoning of the actual cost after it has been made. Both are extremely important in any factory and cannot possibly be neglected. Budgetary control and the statistics which it requires may be omitted if the board and management are content to wait until the end of each year to learn how the business has gone, but without estimating and costing the business becomes a pure gamble.

To enable the estimator to do his work with the minimum of labour and the maximum of reliability a system is required. It is not proposed here to enter into too much detail but, as in other instances, a system will be covered briefly in order to bring out the points which must be taken care of. There are many systems or variations of systems all of which are more or less satisfactory provided, in all cases, one basic condition is observed. This condition is that the rules and formulae laid down for the estimator must line up with the calculations of the man who estimates the various items for the budget and draws up the profit and loss account at the end of the year. That is to say, it must be made quite certain that the estimator takes into account every single item of expense incurred in the running of the business whether it be material, labour, or overheads, so that when in due course the orders are received and executed, the anticipated financial results will be achieved.

Estimator's Data

For this reason the person who draws up the budget should revise the constants in the estimator's formulae accordingly. If the estimator uses the percentage on labour method for overheads, then he must be given a revised percentage to work to immediately the budget has been compiled to ensure that his estimates will line up with it. At the beginning of the financial year, therefore, the general manager will give the estimating section—

The average material consumption percentage;

The direct labour oncost for the previous year;

The ratio overhead charge to direct labour charge; or

The point value to be used for the overhead charge, the figures being arrived at from the budget.

Throughout the year these figures may be revised at intervals depending on the state of the business. If the monthly report figures are steady, probably no revision is necessary, but if events cause them to move one way or the other a revision must be made. Most concerns state on their quotations that the figure put forward is only firm for a definite period, usually thirty days, so that the right is reserved to revise it if the order is not placed within that time, but few seem to take advantage of it. Obviously, however, if it is found necessary to revise the basis for estimating, all quotations outstanding should, if possible, be revised in line.

Quotations

Frequent revision of the estimator's basis for working is generally considered undesirable because one cannot proceed on the assumption that the customer will automatically pay the estimated price. This, however, assumes that the estimate and the quotation are the same thing, which should not be so. The estimate must be as near as possible the figure which it will actually cost to do the work in question, whereas the quotation may differ from it, depending on market conditions. It is probably better, therefore, to revise the basis for estimation as often as may be necessary, and then to apply any pruning or addition to the estimated total factory cost which market conditions may call for, as a separate operation to arrive at the quotation. Thus the profit or loss percentage at which quotations are going out is immediately revealed.

It should be borne in mind that the cost clerk can and must be exact, but the estimator cannot be exact and has, therefore, to develop discrimination and judgment. This does not mean that in estimating, guess-work or even intelligent guess-work is good enough. The estimator must be able to determine accurately every factor which may be involved, but only experience will give him the necessary facility in the exercise of judgment in deciding to what extent these factors should be included in his estimate.

Estimating varies in complexity and difficulty from the case of the completely new article, which is unlike anything made before, to the compilation of the cost, item by item, of a complete article made up of a number of parts, the cost of which has been already established. The first is the work of the true estimator, while the latter may be done by a "correspondence clerk" or internal salesman in the sales department, whose main job is the writing of a suitable letter to the customer to accompany the quotation. Although this "secondary" estimating may be done in a different

department, and perhaps should preferably be done by the sales department and not by the factory at all, the true primary estimating should be done in the same office as the costing, so that the information which is constantly amassed by the latter operation may be readily available to assist the former.

The amount of assistance which the cost estimator receives from other people varies in different factories, but, generally speaking, the bigger the factory the more restricted is the work of the estimator. In a large, well-organized factory the drawings and parts list for what is to be a new product go to the planning department, so that the various operations which will be required may be schemed out and set down. The planning department will also put against each operation the estimated labour time and the class of operator required. This information, together with the materials list, will go to the estimator. The cost of each item of material is obtainable from the records kept, and will usually be entered by the estimator. His work then becomes the task of writing down, item by item, the cost of the material, the cost of the labour involved in each operation through which the material passes until it becomes the final article, the addition of various allowances, and finally the addition of the appropriate overhead charge.

Allowances for Inefficiency

Even though so much is done for him, the estimator still has one very important task—the estimation of the allowances to be made for inefficiency and it is here that the statistics compiled by the costing section are so useful. The planning engineer or rate-fixer who sets down the labour time for each operation must, as closely as he possibly can, arrive at the time which an operator of average skill and energy will take to do it. The fact that, at any rate to begin with, the operator will probably not perform the operation in such a short time, whereas once he becomes skilled he will perform it in a shorter time, is the business of the estimator. To look at it another way, the planner must set a target whereas the estimator must see that the amount of money shown by his estimate will be enough to cover those cases where the target has been missed.

It has already been pointed out how the rate or point value set for an operation becomes the basic direct labour cost for that operation, provided the operator's performance is equal to the rate, but where the operator fails to reach the rate or records points below standard (P.B.S.) the cost will be higher than the set rate. From the weekly wage analysis and from the examination of actual costs,

the estimator can decide what allowance he should make to cover this item and add it to the labour cost equivalent to the actual rate set.

In the case where a relatively small quantity is to be made, the estimator may set down a direct labour figure which exceeds the rate-fixer's figure, while on a contract extending over a longer time he may consider that on the average there will be no points below standard to be allowed for. Finally, in the case of a very long term contract he may, if competition demands it, set down a lower figure than that corresponding to the rate by taking into account the fact that after the first few weeks the operator will probably earn bonus, i.e. he will register points above standard (P.A.S.). It is very important to note that working at points above standard will only cancel out working at points below standard if the rate paid for points above standard is less than the all-in labour rate and that, even where there is a difference, it is probably relatively small and therefore it takes several points above standard to cancel out one point below.

Example

To make this clear by way of an example, take an operator whose basic rate is 1s. per hour plus 33s. 6d. cost of living bonus per week of 47 hours. Suppose this operator is put on a job having a point value of 60, if he does the job in exactly one hour it costs 20·55 pence, this being the cost corresponding to the rate-fixer's time. If, however, he takes 75 minutes (15 P.B.S.) the job will cost 25·65 pence, because, although he is working at points below standard, he must be paid a minimum of 20·55 pence per hour. If the rate for bonus points is also 20·55 pence per 60 points, then no matter how fast he works, the cost each will still be 20·55 pence, so that no amount of working at P.A.S. will compensate for previous working at P.B.S. If, however, bonus points are paid for at, say, 12 pence per 60 points and the operator does one piece in 45 minutes, he will be paid for 45 minutes at 20·55 pence per hour plus a bonus of 15 points at 12 pence per 60 points, i.e. 3 pence, so that each piece will cost 18·4 pence, showing a saving of 2·15 pence each, and thus each piece produced at 15 P.A.S. will compensate for $\frac{1}{2{\cdot}4}$ piece produced at 15 P.B.S.

On a piece-work system the price is usually fixed so that the bonus rate corresponds to the basic hourly rate, excluding cost of living awards. Thus again a saving in direct labour cost is made

when a bonus is earned. In the case quoted, where the time per job arrived at by the rate-fixer is 60 minutes each, the piece-work price would be fixed at 12 pence each, but the cost per job would still be 20·55 pence. If the operator does one per 45 minutes he would get 1s. each plus 8·55 pence per hour worked, so that again at 45 minutes each the cost of the article would be 18·4 pence.

To arrive at formulae let—

R = Operator's basic rate in pence per hour.

$C = \frac{\text{Cost of living bonus}}{47}$ in pence per hour.

A = All-in rate $= R + C$. „ „

T = Time in minutes established by the rate-fixer for the job.

V = Point value $= T$.

B = Price paid for 60 bonus points.

P = Piece-work price $\times \frac{W}{60} \times T$.

W = Basic rate of class of operator for particular job in question.

O_a = Operator's actual time in minutes when working at P.A.S.

O_b = Operator's actual time in minutes when working at P.B.S.

M_s = Minutes saved $= P_a$.

M_l = Minutes lost $= P_b$.

On Piece-work System:

$$\text{Direct Labour cost} = D = P + \left(\frac{C}{60} \times O_a\right) \text{ working at P.A.S.}$$

$$D = \left(\frac{R + C}{60}\right) \times O_b \text{ working at P.B.S.}$$

On Points System:

$$D = \left(\frac{A}{60} \times O_a\right) + \left(\frac{(V - O_a) \times B}{60}\right) \text{ working at points above standard.}$$

$$D = \frac{A}{60} \times O_b \text{ working at P.B.S.}$$

Therefore each point below standard costs $\frac{A}{60}$ but each point above standard saves $\frac{A - B}{60}$

$$E = \frac{\text{Cost of P.B.S}}{\text{Value of P.A.S.}} = \frac{A}{A - B}$$

TABLE D VALUE OF E

(All-in Rate Pence per Hour)

Hourly rate in pence corresponding to P.W. price or Bonus Rate Pence per 60 Points	14·55	15·55	16·55	17·55	18·55	19·55	20·55	21·55	22·55	23·55	24·55	25·55	26·55	27·55	28·55	29·55	30·55
6	1·7	1·63															
7	1·93	1·82	1·73	1·66													
8	2·22	2·06	1·94	1·84	1·75	1·7	1·63										
9	2·62	2·37	2·19	2·05	1·94	1·85	1·78	1·72	1·66								
10	3·2	2·8	2·52	2·33	2·17	2·05	1·95	1·87	1·8	1·74	1·69						
11	4·1	3·42	2·98	2·68	2·45	2·29	2·26	2·04	1·95	1·87	1·81	1·75	1·71				
12	5·7	4·4	3·64	3·16	2·83	2·6	2·4	2·26	2·14	2·04	1·96	1·89	1·82	1·78	1·73		
13	9·4	6·1	4·66	3·86	3·35	2·98	2·72	2·52	2·36	2·23	2·12	2·05	1·96	1·9	1·84	1·79	1·74
14			6·5	4·95	4·07	3·52	3·14	2·86	2·64	2·46	2·32	2·21	2·12	2·04	1·96	1·9	1·85
15				6·9	5·2	4·3	3·7	3·3	2·98	2·75	2·57	2·42	2·3	2·2	2·11	2·03	1·96
16					7·3	5·5	4·5	3·88	3·44	3·12	2·85	2·68	2·52	2·39	2·28	2·18	2·1
17						7·7	5·8	4·75	4·06	3·6	3·25	3	2·78	2·62	2·47	2·36	2·26
18							8·05	6·1	4·95	4·25	3·75	3·4	3·1	2·9	2·71	2·56	2·43
19								8·5	6·35	5·2	4·4	3·9	3·52	3·23	3	2·8	2·65
20									8·8	6·65	5·4	4·6	4·05	3·65	3·35	3·1	2·9
21										9·25	6·9	5·6	4·8	4·2	3·8	3·46	3·2
22											9·65	7·2	5·85	5	4·35	3·92	3·58
23												10	7·5	6·1	5·15	4·5	4·05
24														7·8	6·3	5·3	4·7
25															8	6·5	5·5
26																8·3	6·7
27																	8·6

By substituting the figures for the example given in the above, the figure of $E = 2{\cdot}4$ is obtained. The Table D gives E for operators at various basic rates, plus 8·55 pence per hour C.L.B. Having arrived at the value of E the estimator then has to decide what proportion of the order is likely to be completed at P.B.S. and what at P.A.S. and an average figure for each case. Here, only experience coupled in important cases with consultation with the planners, rate-fixers, and foremen is the only guide. A price adjustment is therefore arrived at as follows—

$$\left[\left(X\% \times P_b\right) - \left(\frac{Y\% \times P_a}{E}\right)\right] \frac{A}{60 \times 100}$$

This may be positive or negative. Assuming, in the case already dealt with, that 1000 parts are to be made, and it is assumed that 150 will be done on the average at 15 P.B.S. and 850 on the average at 15 P.A.S., the price adjustment would be—

$$\left[\left(15 \times 15\right) - \left(85 \times \frac{15}{2{\cdot}4}\right)\right] \frac{20{\cdot}55}{60 \times 100} = -1{\cdot}05 \text{ pence}$$

It is interesting to note the special case where working at P.B.S. may be neglected. Then $Y\% = 100$ and the formula simply becomes—

$$\text{Price adjustment} = -\frac{P_a}{E} \times \frac{A}{60}$$

Going back again to the example it is—

$$\text{Price adjustment} = -\frac{15}{2{\cdot}4} \times \frac{20{\cdot}55}{60} = -2{\cdot}15 \text{ as previously arrived at.}$$

The Table for E and the formula for the price adjustment may be applied to the piece-work system, but in this case the figures in the left-hand column of the table are hourly rates corresponding to piece-work prices. For example a piece-work price of 7d. for a job timed to take 30 minutes is equivalent to a rate of 14 pence per hour. If the operator put on to such a job receives 20·55 pence per hour all in, the figure E is 3·14. If this operator does the job in 22½ minutes and therefore saves 7½ minutes, the adjustment in cost is—

$$-\frac{7\frac{1}{2}}{3{\cdot}14} \times \frac{20{\cdot}55}{60} = -{\cdot}81 \text{ pence}$$

The main value of the table in the case of the piece-work system is to cover instances where a job on which the piece-work price was

originally fixed to correspond to the basic rate of a certain class of worker, is done by a worker getting a different basic rate.

Line Production

As already stated, the rate-fixer studies each operation and determines a time for it. The estimator then takes this time and applies any labour efficiency correction he may decide is appropriate. It is very important to note, however, that the basic labour cost of the job as a whole is only equal to the sum of the basic labour cost of each operation if all the various operations can proceed independently at maximum speed. This may not be so in a line assembly job.

Take the case of an article made from sheet steel by a process of blanking, forming separate parts and then welding the whole together. The blanking of the various parts and the subsequent forming of them in presses may be arranged in batches independent of the welding in such a way that these operations can all proceed at maximum speed. If the rate at which any one part can be produced exceeds the rate at which the complete article is being produced, a run would go through on a press to produce several weeks' requirements, and then the press would be changed over to another part for this job or to something else altogether. If this is the case, then, clearly, the estimator is justified in simply adding together the basic labour costs of the respective parts to arrive at a figure for the whole.

With regard to the actual welding of the parts together to form the final article, however, a different treatment is required. A production line would be established along which the job is to pass, each welding operation being done in sequence. Supposing there are four welding operations which, when timed separately, show the following—

Operation	1	2	minutes
„	2	1·5	„
„	3	0·5	„
„	4	1·25	„

Everything now depends on the rate of production. The minimum rate must be 30 per hour, but if it is no higher, then something must be done to combine operations 3 and 4 together. Assuming this can be done, there will still be three operators turning out 30 complete articles per hour, so that the cost will be equivalent to six operator-minutes each, whereas the total of the above is 5·25 operator-minutes.

If the production rate can be 120 per hour, it would be possible to arrange the following—

Operation	1	2	minutes	(4 operators)
„	2	1·5	„	(3 operators)
„	3	0·5	„	(1 operator)
„	4	1·25	„	(3 operators)

Thus, 11 operators would turn out 120 complete articles per hour between them, and therefore the cost of each article would be equivalent to 5·45 operator-minutes. Clearly, the larger the output the closer the operations can be balanced, and therefore the nearer the total labour time is to the simple addition of the individual labour times.

Group Bonus Schemes

Incidentally, a group bonus scheme is preferable in such a case. If the operators are paid bonus on individual effort, then where the output is 30 per hour Operator No. 2 will work at his maximum speed until he has caught up, and will then book on to waiting time until there is an accumulation of parts from Operation No. 1. Thus his actual earnings will be a maximum and the cost of the job will be inflated. If the operators are paid a group bonus they will help each other out so that, for instance, Operator No. 2 might change over periodically with Operator No. 1 in order to give the latter a rest, and the performance of the team would probably then improve. Also, of course, a group bonus scheme simplifies checking, time booking, and therefore costing statistics.

To establish the direct labour figure in the actual cost, the cost clerk takes from the production cards previously referred to the particulars for a given batch. From this information he is able to extract the actual labour cost, automatically including the cost of P.B.S. or the advantage accruing from P.A.S. He must then add the direct labour oncost by applying the percentage ruling for the period during which the batch was produced, but before proceeding he should compare his figures with the estimate. When the estimate was made up the estimator assumed that the article in question would be produced at a certain rate, and whether the overhead was applied as a percentage on labour or was based on time, the fact remains that if the correct amount of money is to be recovered, the cost clerk must take the actual speed of production into account. If he finds that in actual practice the articles are being produced at a slower rate than the estimate, not only will he set down in his actual cost a higher labour figure, but he must also put down a

higher figure for the overhead charge while, if the rate of production exceeds the estimate, he may, with justification, insert a lower figure.

However, before inserting figures lower than the estimate consequent upon a greater rate of production, he should satisfy himself in regard to another point. He must check up to see whether the apparent saving in time is genuine, this being shown by the lost-time figure for the operator in question. The operator may, for instance, turn out a number of pieces at the rate of 45 minutes each against a rated time of 60 minutes, but the saving which this performance represents is immediately reduced if for some reason he has to book off the job on to lost time to a greater extent than normal. For example, if everyone has assumed that the operator will not be able to do better than 50 minutes each, he may run out of material and be idle while some more is being found for him. Unless carefully guarded against, there will often be instances where an operator has shown a good performance for a batch, but has subsequently booked an excessive amount of lost time.

Saving from Increased Rate of Production

Assuming that the cost clerk finds the operator, to whom the card he is handling applies, did achieve a genuine good performance unspoiled by a subsequent hold-up, he may with justification enter as his direct labour cost the figure shown by the production card. Having increased this by the direct labour oncost percentage ruling at the period, he may then proceed to take care of the overhead charge. Now the estimator, since he is dealing with something which has not yet been done, must use some sort of formula to arrive at an overhead charge which, as already discussed, should on the average yield the necessary contribution to overhead expenses, but the cost clerk who is setting down the actual cost of something which has been done must, as far as possible, include an overhead charge which really does correspond to the proportion of overhead expenses which have been incurred during the time over which the job was done. Consequently, the amount entered by the cost clerk will often be different from that put down by the estimator.

It is interesting to note the results which are given if the cost clerk follows either of the two systems already discussed. Taking again a case where the budget shows a ratio of 200 per cent for overhead expenses against direct labour, and assuming the estimator uses the percentage on labour method, the cost *estimate* (omitting material) for a job might be as follows—

Estimated time per piece	60 minutes.
Operator's rate	1s. plus 8·55 pence per hour.
Piece-work rate	12 pence each, or
Point value	60 points.
Bonus points at 12 pence per 60 points.	
Allowance for P.B.S. or P.A.S.	NIL.
Basic direct labour cost	20·55 pence.
Direct labour oncost 20%	4·11 ,,
Direct labour cost	24·66 ,,
Plus 200% overhead charge	49·32 ,,
	73·98 pence.

If the operator turns out these parts at the rate of one per 45 minutes and investigation shows that the performance is genuine, it is clear that, quite apart from any saving in labour cost, more parts are being produced per day or week and, therefore, if the overhead charge levied on each is still 49·32 pence, the overhead recovery is greater than is required to meet overhead expenses. It would, therefore, be more correct to reduce the overhead charge in the cost make-up and show a profit due to the increased rate of production. Of course, careful consideration must be given to all sorts of factors before it is safe to pass on this reduced cost to a sales organization or to a customer, but, nevertheless, for the batch in question the cost is less and should be shown as such if only to stimulate an inquiry if, and when, a higher figure emerges at a later date from figures shown against other batches.

Consequently, in the case where the cost clerk uses the percentage on labour method, he would show for the batch turned out at the rate of one per 45 minutes—

	Pence
Basic direct labour	18·4
Plus 20%	3·68
Direct labour cost	22·08
Plus 200%	44·16
	66·24

Alternatively, using the time basis method for overhead charge, it would be—

	Pence
Basic direct labour	18·4
Plus 20%	3·68
Direct labour cost	22·08
Overhead 45 points at 0·82 pence	36·9
	58·98

It will be seen that the first method reduces the overhead charge only in proportion to the direct labour cost which, for the reasons already dealt with, is only 10·4 per cent, although the time taken is reduced by 25 per cent, i.e. the output is increased by 33⅓ per cent. The second method, however, reduces the overhead charge by the full 25 per cent.

It is open to argument as to which method is preferable. The former keeps something in hand, whereas the latter shows the maximum possible reduction. The choice should perhaps depend on what safeguards are laid down to prevent the reduction being passed on to a sales organization or a customer prematurely, but provided this cannot happen it is probably better from the point of view of works control to use the latter method.

Handling Charge on Materials

In many factories it is common to put a handling charge or part of the overhead charge on to material. This must be treated with care and clearly distinguished from a material wastage allowance. To be correct the percentage which is added as a proportion of the overheads should be arrived at by taking the various items of overhead expense created by the stores and the handling of materials into stores, and equating this to the value of the material consumed. It must not be taken as a percentage of the material in stock because, unless the material is moved out of the stores and incorporated in finished articles, it will not earn a corresponding overhead recovery.

If it is decided to apply such a percentage, the figure would be established from the budget and given to the estimating section along with the figure to be applied for the balance of the overheads. In addition, however, the estimator must also apply a percentage for material wastage. The material wastage for the year may be arrived at by comparing the material consumption with the total bare material extracted from the estimates for the total of the work done. There is no reason why the estimated value should not be very accurate, and it is a comparatively simple if tedious matter to take the year's output item by item and calculate the total value of the material used, assuming no wastage. Clearly, the difference between this total and the actual material consumption shown as a result of stocktaking is the material wastage.

It is assumed that the purchase ledger will have been given all credits for scrap disposed of. To arrive at a true figure for the wastage in manufacture, any reduction which has been made to

ESTIMATE

Calculated material cost . .	A		
Plus % for material wastage .	B		
Material		C	
Plus % to cover proportion of overhead charge . . .		D	
			E
Direct labour corresponding to rate set and class of operator proposed	F		
Plus adjustment for P.A.S. and P.B.S.	G		
Basic labour		H	
Plus % to cover direct labour oncost		K	
Direct labour			L
Plus % on direct labour to cover overhead charge . . .			M
Total basic Factory Cost . .			$E + L + M$
Add percentage for Factory Profit			$= N$
Total estimated Factory Cost .		(X)	$= E + L + M + N$

COST

Direct material from requisitions issued or from production records . . .		O	
Plus % to cover proportion of overheads .		P	
Material cost			Q
Basic labour cost from production records .		S	
Plus % to cover direct labour oncost . .		T	
Direct labour cost			U
Plus % to cover overhead charge . .			V
Total actual Factory Cost (Y) . . .			$Q + U + V$

the stock by way of writing down obsolete or other materials (other than materials rendered of less value by work done on them in the factory) will be taken out of the calculation and, as already described, the labour and overhead content in the work in progress must not be allowed to appear as if it were material. Similarly, if a percentage is added to material to cover part of the overheads, this must not be put on the work in progress when calculating material wastage. To sum up, therefore, the systems followed respectively by the estimator and the cost clerk are set out on page 159.

The difference between the total Estimated Factory Cost (X) and the Total Actual Factory Cost (Y) is the true profit made, unless the quotation was less than the estimate.

Using the time basis for the overhead charge, the systems are similar except that items M and T, respectively, are worked out as already shown.

INDEX